



Storage Tank Venting

A compendium of articles

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STORAGE TANK VENTING COMPENDIUM

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Class III-B liquids and Emergency Venting of ASTs

Scott Stookey, Senior Technical Staff
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Recently ICC was asked to explain the requirements for emergency venting of atmospheric aboveground storage tanks (ASTs) storing Class III-B combustible liquids. This inquiry was based on the requirements in the 2012 *International Fire Code (IFC)*.

Class III-B combustible liquids are those with a closed cup flash point temperature greater than 200°F. Class III-B liquids comprise a broad family of common products including lubricants, cooking oils and heavy bunker fuels used in marine diesel engines. This article explains the 2012 IFC and 2012 edition of NFPA 30, *Flammable & Combustible Liquid Code* emergency venting requirements for ASTs storing Class III-B liquids.

The requirements for emergency venting of ASTs storing Class III-B liquids are found in IFC Section 5704.2.7.4. Under the IFC and NFPA 30, an AST with a volume of 12,000 gallons or less storing Class III-B liquids requires an emergency vent. If the tank is located inside a building, the tank's emergency vent is not required to be terminated outside the building.

For an AST that contains a Class III-B liquid with a volume exceeding 12,000 gallons, an emergency vent is not required, provided the tank is not located in the same containment dike or drainage path for other tanks that contain Class I or II liquids (see the exception to IFC Section 5704.2.7.4). If a tank containing a Class III-B liquid is located within the same dike or drainage path with Class I or II liquids, an emergency vent sized and installed in accordance with NFPA 30 is required. The IFC requirement exactly parallels the requirement in NFPA 30, Section 22.7.1.1.3. All UL 142 listed ASTs are constructed with one or more nozzle openings for an emergency vent that is sized based on the tank's wetted area.

You might wonder why Class III-B liquids would ever be excluded from code requirements for emergency vents. Conceptually, the Class III-B exception is based on several factors:

1. Class III-B liquids have high boiling points, which means that a great deal of heat from an exposure fire must be transferred to the liquid in a tank to elevate the liquid on the inside of the shell surface to its boiling point, at which time vapor produced by boiling becomes a venting concern.
2. Class III-B liquids are known to have high values for latent heat of vaporization. Latent heat of vaporization relates to the quantity of heat required to accomplish a phase change from liquid to vapor when the liquid is at its boiling temperature. So, even after a Class III-B liquid reaches its boiling temperature, a significant quantity of heat must still be added from a fire exposure to overcome the latent heat of vaporization and produce large quantities of vapor that must be vented.
3. Class III-B liquids, having a high molecular weight, produce less vapor per pound of liquid vaporized versus liquids with low molecular weight. This slows the rate of pressure increase inside the tank when a fire exposure is experienced.
4. Class III-B liquids are difficult to ignite, so a Class III-B liquid tank that is not in the same diked area or drainage path for a Class I or Class II liquid is unlikely to be subject to a severe fire exposure around the tank perimeter.
5. If the pressure in the tank remains close to atmospheric without an emergency vent until the tank shell above the liquid level fails due to fire exposure, then an emergency vent is not needed.

With the foregoing in mind, you might now wonder why the emergency venting exception for Class III-B liquids only applies to tanks exceeding 12,000 gallons capacity. The answer to that question relates to

historic testing and observation that is documented in NFPA 30 and API 2000, which demonstrated that, as the size of a tank increases, the heat input to the tank due to a fire exposure tends to drop because it is more difficult for a fire to continuously and fully engulf a large tank in “optically thick” flame than a small tank. Accordingly, small tanks, even those with Class III-B liquids, are expected to experience rapid heat input, temperature rise and vapor production, placing them at risk of an explosive rupture without an emergency vent. The 12,000 gallon value in the exception was first published in the 1972 edition of NFPA 30, and it was reportedly the result of a consensus agreement of experts serving on the NFPA 30 committee at the time to be a reasonable cutoff for the allowance of unvented tanks.

Below is a link to an investigation report prepared by the US Chemical Safety and Hazard Investigation Board (CSB) about a petroleum packaging plant in South Texas that was destroyed by a fire and explosions in 2003. A contributing factor to this incident was locating ASTs storing Class III-B liquids without emergency vents in the same containment dikes with ASTs storing Class I and II liquids. This CSB report reinforces the importance of compliance with IFC Section 5704.2.7.4 and NFPA 30 Section 22.7.1.1.3.

http://www.csb.gov/investigations/detail.aspx?SID=40&Type=2&pg=1&F_State=TX

The International Code Council publishes *2009 Fire Opinions: Q&A* which contains over 270 staff opinions on the various requirements in the *International Fire Code*, including opinions on aboveground storage tanks and requirements for motor vehicle fuel-dispensing. A searchable electronic file and a printed soft cover book are available from ICC for \$40.00. To purchase, call 800-786-4452 or go to

<http://www.iccsafe.org/Store/Pages/Product.aspx?category=0&cat=ICCSafe&id=4410S09>.



Tank Talk, April 2013

Revisiting Gadsden: Why tank maintenance is vital

by Scott Stookey, fire code expert

Storage tank fabricating standards, fire codes, maintenance requirements—all are intended to protect people and property from the inherent risks in storage of flammable liquids. None of these measures, though, offer safety if they are not implemented and enforced consistently.

The tragic fire and explosion at a service station near Gadsden, Alabama, in 1978 is a case in point. A UL 142-compliant tank was the source of an explosion and fire, due to multiple factors that might have been prevented if maintenance codes and procedures had been followed.

What happened

During a fill operation at a gas station and storage facility, a tanker truck driver was delivering gasoline to two 6,000 gallon above ground tanks. Unknown to the driver, a brass gate valve at the tank bottom was cracked. As the tank filled, gasoline began to leak onto the ground. Since the tank was not diked, gasoline flowed over the graveled area for 20 minutes. Some of it vaporized into the still air.

At the transfer pump, vapors ultimately penetrated the space between energized wires in an uncovered electrical junction box at the jump motor. The ignited vapors caused the spilled gasoline to burn, engulfing the area. In five minutes, the tanker's discharge hose burned through, releasing gasoline from the truck, intensifying the fire.

Now the fire was



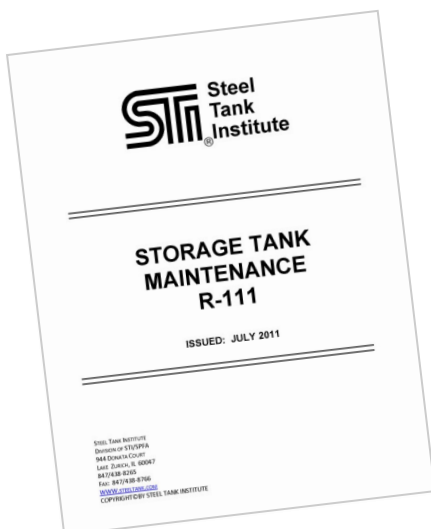
Three firefighters were killed in the 1978 Gadsden tank explosion and fire, and another died a year later of his injuries. Twenty-eight people were injured. Photo courtesy NTSB Special Investigation Report,

continually fed both by leaking from the gate valve and from the tanker truck. Ultimately, the second above-ground tank's vapor vent "whistled" and internal pressure caused the weld seam to crack. When the tank head blew, even more gasoline was added to the conflagration.

Causes of the incident

The National Transportation Safety Board (NTSB) performed a Special Investigation of the Gadsden tank fire. In its report, the NTSB noted several causes of the incident:

NFPA code at that time did not permit above ground gasoline storage at service stations. However, separate regulations intended to "grandfather" existing facilities were promulgated. Understanding the risks involved, NFPA requires additional safeguards including explosion relief vents, spill control dikes, codes for use of an auxiliary electrical transfer pump, and automatic and manual fuel shutoff devices on the delivery vehicles.



However, NFPA Code also permits waiver of these requirements “at the discretion of the authority having jurisdiction...” and that existing equipment “not in strict compliance ...may be continued in use provided they do not constitute a recognized hazard to life or property.”

The Alabama State Fire Marshal had waived NFPA requirements for this

existing facility. It was in a rural area and thus deemed less hazardous. Further, personnel shortages meant that priority inspection time was given to facilities in the city of Gadsden proper.

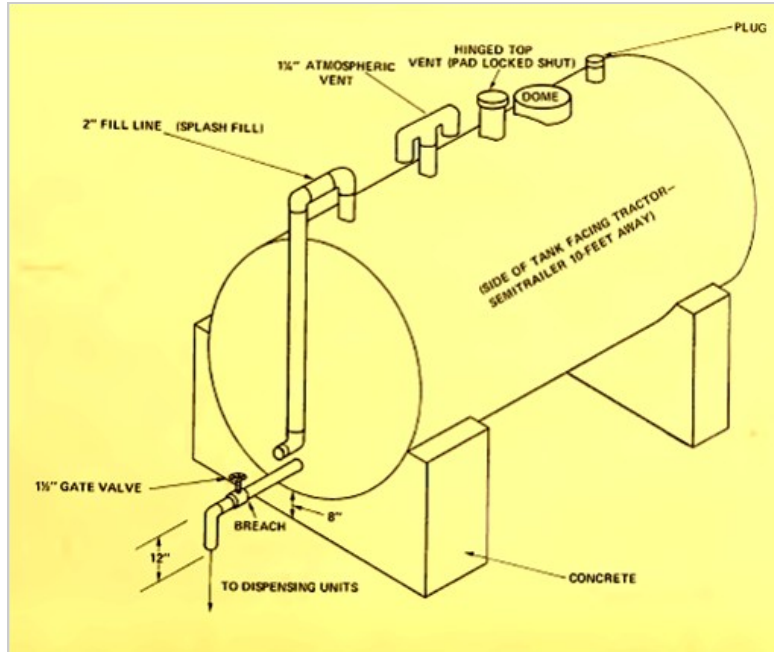
The firefighters called to the scene were uninformed as to the hazards posed by waiver of NFPA 30 requirements for the explosion site. Their understanding of above-ground storage tank safety requirements may have lead them to expect that the leaking storage tank was diked, that emergency vents on the storage tanks were operational, and that emergency cut off switches were operable.

Therefore, the firefighters focused on the burning tanker truck as the greatest hazard to imminent explosion. In fact, they had this fire under control when the second storage tank exploded catastrophically.

Inspection and maintenance are vital

Inspection and maintenance to detect non-compliant conditions might have prevented the loss of life that occurred in the Gadsden accident. Tragically, none of the expected safeguards was in place:

- Piping at the bottom of the exploded second tank was unprotected by a dike.
- The flow valve at the tank bottom was brass rather than steel and was cracked due to impact at some earlier time.



- The tanker’s fill pump was designed for permanent installation, with fixed wiring, a cover plate and hold-down screws to prevent flammable vapor entry. However, on this occasion the pump was used in a portable capacity. The cover plate and hold-down screws were missing.

- Fusible-core nuts (made of lead, for example) are required on the spring-loaded lever-and-

valve mechanism at the discharge pipes on the truck. However, these nuts had been replaced with non-fusible nuts; when the dispenser hoses melted, the tanker’s stored gasoline provided the hottest source of the fire.

The “whistling” emergency vent

The final factor in the scope of the Gadsden explosion and fire was that the emergency vent on the exploded tank had been *padlocked closed*. The fire fighters heard the whistling of the vent as pressure built in the tank, but did not understand that it should not be occurring. Thus, they were close to the tank when it exploded.

Any of these hazards might have been avoided had the facility’s storage tanks been in compliance with NFPA’s requirements for above ground storage of flammable liquids. Even if that was deemed not feasible, routine inspection by a qualified individual would most likely have exposed the cracked brass flow valve at the bottom of the tank that was the primary cause of the incident.

Gadsden: one of too many

The NTSB’s report on the Gadsden tank explosion and fire made several recommendations for code clarification, enforcement and tank inspection. Since 1978, of course, many of these have been incorporated into NFPA and other codes and standards.

Nonetheless, every once in a while, a tragic tank fire occurs. While inspection and maintenance by qualified

personnel can't prevent all such incidents, it can surely enhance public safety by recording hazards and enforcing fire safety compliance.

The Steel Tank Institute has developed two documents about inspection and maintenance to help tank owners, operators and regulators avoid incidents like the Gadsden fire:

- **R111, Storage Tank Maintenance:** This document discusses actions to take when changing fuels, as well as monitoring tanks for the presence of water and contaminants. Removal of water and other contaminants is included.
- **SP001, Standard for the Inspection of Aboveground Storage Tanks:** This Standard provides inspection criteria for determining the suitability for continued service of aboveground storage tanks. Included in tank inspections are tank components such as gauges, valves, normal and emergency vents, and of course, the tank itself.

STI also has a training program for certifying tank inspectors. Information about this program is available at www.steeltank.com.

Scott Stookey is a fire code expert, formerly with the International Code Council. He currently applies his expertise for the /Austin Fire Department.

Tanks Inside Of Buildings – to Vent or Not to Vent, That is the Question

Scott Stookey, Senior Technical Staff, International Code Council – Austin, TX

Some *TankTalk* readers may consider it inappropriate to misuse a common stanza from the Shakespeare play “The Tragedy of Hamlet” and I hope the title doesn’t offend you or inhibit your enjoyment of the arts. However, the title paraphrases a question that is commonly asked of ICC staff because of the issues surrounding AST installations inside of buildings.

The storage of flammable and combustible liquids in ASTs inside of buildings requires the fire code official to apply more rigorous provisions from the 2012 *International Fire Code*[®] (IFC[®]) and NFPA 30, *Flammable and Combustible Liquids Code*. For tanks designed to store liquids with a closed cup flash point temperature below 200°F (Class I, II and IIIA liquids) at atmospheric pressure, the requirements are justified because flammable and combustible liquids exhibit much higher heat release and burning rates when compared to many ordinary combustibles found in buildings. One of the requirements pertains to the termination of normal vent and emergency vent of ASTs inside buildings, and that’s the subject of this article.

TINBIDS (**T**anks **I**nside of **B**uildings) are fairly common in commercial development projects. Over the past 10-15 years, the demand for standby power systems that provide an alternative source of electrical energy to computer servers and similar equipment has increased dramatically. Designers commonly specify engine-driven generators with integral sub-base ASTs to limit the floor area of the standby power source. The TINBID requirements in Chapter 57 of the 2012 IFC become applicable when any AST containing Class I, II or IIIA liquids is installed indoors. The IFC requires a construction permit to install a TINBID as well as an operational permit to ensure that it is properly maintained in accordance with all of the IFC requirements.

Normal Venting

In addition to the requirements for tank construction, volume limits and overfill protection, the IFC has requirements for terminating a TINBID’s normal vent and emergency vent. The purpose of the normal vent is to maintain the pressure inside of the tank when liquids are introduced into or are withdrawn. All storage tanks are designed to resist the vacuum and positive pressures generated when liquid is introduced into or withdrawn. Improperly sizing a tank’s normal vent or obstruction of the vent can cause excessive negative pressure to generate inside the tank, causing the tank to collapse into itself. IFC Section 5704.2.7.3 has a number of provisions to ensure the normal vents are properly terminated. For Class I, II and IIIA liquids the IFC requires termination of the normal vent outside the building. It should be located at least 12 feet above the finished ground level and a minimum of 5 feet from building openings and lot lines that can be built upon. The 12-foot elevation of the vent is necessary to ensure that the surrounding air mixes with the vapor being exhausted from the tank so the atmosphere is maintained below 25% of the liquid’s lower flammable limit.

PV vents are required by IFC Section 5704.2.7.3.2 on the normal vents of TINBIDS containing Class IB or IC liquids to limit the potential release of flammable vapors. A PV vent only operates when product is withdrawn or added to the tank. In lieu of a PV vent, the 2012 IFC will now permit the installation of in-

line flame arrestor. A flame arrestor is a mechanical device designed to absorb and dissipate the energy of a flame. If a flame arrestor is selected as a means of protecting the tank's normal vent, it must be designed and installed in accordance with API 2028. Note that when specifying flame arrestors, a number of technical concerns must be addressed including:

- Properly sizing the flame arrestor. A flame arrestor operates by absorbing heat using highly conductive metal such as brass or aluminum installed so it fills the cross-sectional area of the vent pipe. Improperly sized arrestors can obstruct the flow of air during liquid dispensing or withdrawal operation. Such an obstruction can cause transfer pumps to cavitate or create a vacuum pressure which could damage the primary containment.
- Debris loading. Class I liquids commonly act as solvents and can be electrically conductive. As a result, vapors with a positive electrical charge can attract and accumulate dust, dirt and other debris. Because the solvent may adsorb or detract water, the removal of moisture causes the debris to accumulate. The design of the normal vent needs to accommodate the maintenance and cleaning of the flame arrestor of debris.

Emergency Venting

With the exception of ASTs larger than 12,000 gallons that contain Class IIIB liquids that are located so they cannot be affected by a release of Class I or II liquids, IFC Section 5704.2.7.4 requires all TINBIDS be equipped with a means of emergency venting. Emergency venting is a pressure relief device designed to protect the tank from being overpressurized beyond its design limits so it does not rupture. The IFC requires the emergency vent be installed and maintained in accordance with NFPA 30, Section 22.7.

Installation of a TINBID introduces additional requirements for the tank's emergency vent. The IFC prohibits the discharge of an emergency vent inside a building. The primary reason for this provision is the emergency vent's function. When an emergency vent opens, it depressurizes the storage tank by relieving vapor generated by a fire. This vapor, if not discharged outside the building, could add vaporized fuel to an unwanted building fire. If enough vapor is released before it finds a fire or ignition source, the resulting flash fire could create a vapor cloud explosion, causing severe damage to the tank and building, as well as potentially injuring or killing building occupants.

An issue that impacts the design of emergency venting systems terminated outside a building is the addition of pipe and fittings beyond the outlet of the storage tank can create a backpressure inside the tank. This backpressure results from friction of the liquid vapor moving across the interior of the pipe and fittings. NFPA 30 Section 22.7.4 requires piping that is extended more than 12-inches beyond the AST's emergency vent opening be evaluated for this pressure loss. Analysis routinely finds the pipe and fitting diameters may need to be increased beyond the diameter of tank's emergency vent opening to accommodate for this backpressure. The calculations are based on a derivative of the Darcy-Weisbach equation – as a result, the design of emergency vent extension piping should be supervised by a registered professional engineer.

Because of the importance of emergency vents and the additional design challenges that arise for vents protecting TINBIDS, the 2012 IFC was revised to permit the termination of the emergency vent inside the building when combustible liquids are stored in protected aboveground storage tanks. A protected AST is defined in IFC Section 202 as *A tank listed in accordance with UL 2085 consisting of a primary tank provided with protection from physical damage and fire-resistive protection from a high-intensity liquid*

pool fire exposure. The tank may provide protection elements as a unit or may be an assembly of components, or a combination thereof. Exception 2 of IFC Section 5704.2.7.4 allows the emergency vent to be terminated inside the building when the tank is storing Class II or IIIA combustibles liquids. For Class IIIB combustibles liquids, the emergency vent has always been permitted to be terminated indoors.

The code was revised based on calculation of vapor pressure of ultra low sulfur diesel stored in a UL 2085 AST. As a condition of listing a protected AST, UL 2085 prohibits the thermocouple measuring the primary containment from exceeding a maximum temperature of 400°F. Vapor pressure calculations determined that at 400°F, the vapor pressure of the diesel is below the 2.5 PSIG opening pressure specified in NFPA 30, Section 22.7.3.10.1. Based on the fire-resistance and insulating quality of the materials used in the fabrication of protected ASTs, the emergency vent for these tanks storing Class II and IIIA liquids will not operate inside a building.



The change in Section 5704.2.7.4 was developed in response to a code change that was approved in 2009 IFC. IFC Section 603.3.1 was modified to allow increased quantities of fuel oil inside of a building without changing the occupancy to a Hazardous occupancy. The requirements in the 2009 IFC permit up to 3,000 gallons of fuel oil inside a building when:

1. The fuel oil is stored in a Protected AST,
2. The entire floor housing the TINBID is protected by a NFPA 13 compliant automatic sprinkler system,
3. The fuel oil piping system is designed and constructed in accordance with the *International Mechanical Code*, and
4. The PAST is located not more than 2 stories below the building's grade plane.

Readers seeking additional information about changes to the 2012 IFC are encouraged to purchase the *Significant Changes to the 2012 IFC*. This four-color illustrated soft cover provides a detailed analysis of the purpose and intent of the significant code changes to the 2012 IFC. The book can be purchased from the ICC Book Store at

<http://www.iccsafe.org/Store/Pages/Product.aspx?category=15065&cat=ICCSafe&id=7404X12>

ABOUT THE AUTHOR

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Two-Hour Fire Protected Fireguard Tank

Nearly twenty years ago, the Uniform Fire Code first introduced the concept of an aboveground shop-fabricated "protected" storage tank. The protected tank had to be performance tested at 2000 degrees Fahrenheit, with a minimal temperature increase within the tank during the test. The purpose of the test was to safely assimilate an underground storage tank environment with aboveground tank installations that dispense motor vehicle fuels.



Third-party test laboratories followed with the development of construction standards, such as Underwriters Laboratories UL 2085.

Fire codes limited tank capacities to 12,000 gallons for storage and dispensing of gasoline and diesel at retail service stations. However, capacities of up to 20,000 gallons could dispense diesel fuel into motorized vehicles at fleet operations.

Steel Tank Institute developed the Fireguard tank in 1994 and has accumulated interesting statistics. Here is a sampling of STI's findings about users and facts that demonstrate that tanks have doubled in average size since then.

First, 15 percent of all Fireguard tanks are 12,000 gallons or larger.

Second, government agencies have purchased Fireguard tanks as large as 50,000 gallons and such agencies purchase over 25 percent *of all Fireguard tanks*.

In addition, hospitals, schools and other institutions account for 10 percent of installations. Fuel for back-up power generation is a common Fireguard tank installation required or specified by hospitals and utility companies. Further, airports and marinas incorporate many UL 2085 tank installations, and over 50 percent of installed Fireguard tanks at airports are 10,000 gallon capacity or greater.

Interestingly, retail service stations open to the public, while perhaps the most visible Fireguard installations, constitute less than three percent of Fireguard installations, but 40 percent of these tanks are 10,000 gallons or larger.

**Fire Code Requirements for Venting of Flammable and Combustible Liquid Storage Tanks:
Common Questions and Answers
By Jeff Shapiro, PE, FSFPE**

Vent openings are required by fire codes to limit internal pressure and vacuum conditions that might threaten the structural integrity of tanks used for storing flammable or combustible liquids. Such pressure changes may occur for a variety of reasons; however, fire code requirements focus on two, product transfer (the introduction or removal of liquid) and fire exposure.

The two predominant model fire codes in the United States are the *International Fire Code (IFC)*, published by the International Code Council (ICC) and *NFPA 1*, published by the National Fire Protection Association (NFPA). Both of these codes contain regulations that govern the storage of flammable and combustible liquids. In the case of NFPA 1, the regulations are copied from NFPA's *Flammable and Combustible Liquids Code*, NFPA 30, and in the case of the IFC, the regulations are developed by the ICC but tend to be consistent with NFPA codes, which in turn rely heavily on nationally recognized standards that govern tank construction and tank venting including:

- ANSI/UL 142, *Standard for Steel Aboveground Tanks for Flammable and Combustible Liquids*
- ANSI/UL 58, *Standard for Steel Underground Tanks for Flammable and Combustible Liquids*
- API Standard 650, *Welded Steel Tanks for Oil Storage*
- API Standard 2000, *Venting Atmospheric and Low-Pressure Storage Tanks*

Tank venting is a complex subject that relies on the expertise of tank and vent manufacturers, testing laboratories, mechanical engineers who may be charged with designing vent piping extensions, product specialists who must be familiar with the properties of stored liquids, and the local authority having jurisdiction who is charged with interpretation and enforcement of code requirements. Accordingly, the answers offered in this article are general in nature and should not be used in the absence of qualified experts responsible for overseeing the design and installation of tank vents.

With this background in mind, the following is a collection of commonly asked questions and answers associated with fire code requirements for venting of flammable and combustible liquid storage tanks.

Question 1: Fire codes reference two types of venting, “normal” and “emergency.” What is the difference between “normal” and “emergency” venting?

Answer: Normal venting refers to a tank opening that is provided primarily to relieve excess pressure caused by liquid filling a tank and to relieve vacuum that results from liquid being removed from a tank. Normal venting also allows equalization of interior and exterior pressures associated with atmospheric temperature and pressure changes. Emergency venting refers to a tank opening designed to relieve excess pressure caused by a fire exposure to the outside of a tank.

The amount of pressure that must be relieved by normal and emergency vent openings and any venting devices attached thereto, such as spring loaded or weighted caps, can be calculated and must be balanced against a tank's design pressure limits. Normal vents tend to be relatively small in diameter since the volume of air or vapor that must be exchanged to prevent over- or under-pressure due to liquid transfer and environmental factors tends to be small. Although the required vent flow may be calculated, it is typically permissible without calculation to size the vent not less than the greater of 1¼ inches in diameter or the size of the largest fill/withdrawal connection (unless multiple filling/withdrawal connections are provided).

Emergency vents are larger because they must release vapor generated when a tank is engulfed in a pool fire, which is a much larger quantity.

Tanks may, in some cases, be required to accommodate additional venting capacity to handle pressure generated by reactive liquids, heated liquid storage or other unique circumstances, and these considerations are beyond the scope of fire code requirements. API 2000 should be consulted in such cases, and a custom vent design by a qualified engineer may be necessary.

Question 2: Must normal and emergency vents be separate, or may they be combined?

Answer: Fire codes do not require normal and emergency vents to be separate. Provided that the required venting capacity can be met by a single opening or device, only one vent is required. Economics and environmental concerns, however, tend to drive the use of separate devices.

To reduce the risk of igniting escaping vapor and/or reduce the release of vapors that may harm the environment to the atmosphere, many liquids are not permitted by fire codes or environmental regulations to be exposed to the atmosphere through an open vent. In such cases, vents must be equipped with a normally-closed venting device.

Because normal vents must “breathe” in both directions, a pressure-vacuum venting device is needed for a normally-closed vent, which will be expensive in a size large enough to handle emergency vent flows. The more economical solution is to use a small pressure-vacuum venting device on the normal vent and use a pressure-only device on the emergency vent.

Question 3: Is an emergency vent opening or vent device required on all aboveground tanks?

Answer: No. Certain tanks are permitted to have no venting device or to use alternative means of relieving overpressure. Specifically, NFPA 30 does not require tanks storing liquids with flashpoints at or above 200-degrees Fahrenheit (Class IIIB liquids) to have emergency vents when they exceed 12,000 gallons capacity and are not located in an area that might be subject to a pool fire from Class I or Class II liquids stored elsewhere.

NFPA 30 also permits the use of a weak roof-to-shell seam on vertical tanks in lieu of a vent opening. Such seams are designed to fail prior to the remainder of the tank shell when an overpressure condition occurs, allowing excess pressure to be relieved without a significant loss of liquid. Nevertheless, the permissible use of this type of tank design has been restricted in recent years because of concerns that increased internal pressure might fail a bottom seam on some tanks before failing the weak seam.

Question 4: Are multiple normal and emergency vents required for tanks that have multiple compartments or integral secondary containment?

Answer: Yes. Each enclosed space in a tank assembly must be treated separately with respect to venting because any enclosed could individually be subject to an overpressure condition.

Question 5: Is an emergency vent required for underground tanks?

Answer: No. Fire codes only require emergency vents for tanks that are subject to an exposure fire. Buried tanks are inherently protected from an exposure fire.

Question 6: Is it permissible to remove an underground tank and reinstall it aboveground if an emergency vent is added?

Answer: No. The tank construction requirements for underground and aboveground tanks are different, and the lack of an emergency vent is only one differentiating aspect of the design criteria.

Even if an emergency vent is retrofitted onto a steel underground tank, it is still not permissible to re-use the tank aboveground because underground steel tanks are constructed in accordance with UL 58 and aboveground steel tanks must be constructed in accordance with UL 142, which is not an equivalent design standard. Likewise, nonmetallic underground tanks are not designed for use aboveground, and fire codes via reference to NFPA 30 have numerous restrictions on the use of any nonmetallic tank for aboveground storage of flammable and combustible liquids, regardless of whether such tanks are designed for aboveground use.

For these reasons, NFPA 30, Chapter 21 specifically prohibits re-use of underground tanks in aboveground locations and vice versa.

Question 7: Where tanks are installed inside of a building, are there any special requirements related to vent installation?

Answer: Many, and they're changing. Generally, codes require vents for tanks containing flammable and combustible liquids that are installed in buildings, including storage tanks, day tanks on pumps and generators, etc., to be extended to discharge outside. Such a requirement is contained in NFPA 30 Chapters 22 and 27 and in Chapter 34 of the IFC. While this may seem rather straightforward, it isn't.

With respect to normal venting, vent flows for tanks in buildings tend to be low enough that extending a vent pipe can be done without causing excessive backpressure. Care must be taken to ensure that there are no low points that could accumulate liquid, which could come from condensation inside the pipe or from unintended sources, or other obstructions. Any blockage of the pipe could result in excessive backpressure or vacuum inside of the tank. Because the vent pipe must be arranged to generally drain back to the tank's vent opening, provisions must also be made to prevent accumulation of any liquid on top of a venting device, which could impede operation.

With respect to emergency vents, similar precautions against obstruction are needed, but the situation becomes far more serious. UL 142 specifies the minimum diameter for an emergency vent based on a maximum permissible nipple length (pipe connecting the tank shell to the emergency vent opening or vent device) of one foot. When an emergency vent opening must be extended to the building exterior, the additional length through which vapor must flow to escape the tank will lead to excessive back-pressure on the tank if the vent pipe diameter is inadequate. In a worst-case scenario of a fire engulfing a tank with a large surface area, vent flows would be enormous and backpressure from an under-sized vent pipe could cause the tank to rupture.

In addition to the pipe diameter, fittings used to make turns are also a concern because they too are a factor in backpressure calculation.

An early calculation procedure for determining the needed vent size for an extension of vent piping was published in Crane Technical Paper No. 410 in 1957. Other procedures and/or computer programs to execute the calculations may now be available, but the Crane procedure is still valid.

The bottom line with respect to extending emergency vent piping for indoor tanks is to perform the required calculations to ensure that the vent diameter will be adequate to allow enough vapor to release without exceeding the structural design limits for the tank. To accomplish this, expect that the vent diameter may become very large, even for short pipe runs, if the tank has a large surface area/storage volume.

A couple options that may be considered per NFPA 30 Chapter 22 to reduce the vent flow rate and associated pipe diameters are 1) Insulating the tank with a fire-resistive insulating material, 2) Providing an approved water spray system that will wet the tank shell in the event of a fire, 3) Providing a drainage system to remotely drain spilled liquid and minimize the energy of a spill fire. Another option that would allow smaller vent piping and increased back pressure is to use a pressure vessel for liquid storage.

Finally, a new option will appear in the 2012 edition of the IFC. Code Change F204-09/10 modified Section 5704.2.7.4 (previously Section 2704.2.7.4 in the 2009 edition) to allow emergency vents on tanks storing liquids with flashpoints at or above 100-degrees Fahrenheit to discharge inside the building if the tanks qualify as “protected tanks” in accordance with UL2085. Among other enhanced safety features, such tanks are highly insulated and are tested to survive a 2-hour fire exposure with limited temperature increase on stored liquids, which dramatically reduces vapor production inside of the tank.

Question 8: How can an inspector determine whether the size of an emergency venting device is adequate for a particular UL142 compliant aboveground steel tank?

Answer: UL142, Section 48 requires that the nameplate on aboveground tanks specify the required vent flow for emergency venting. Likewise, commercial emergency venting devices are required by NFPA 30, Chapter 22 to be marked with the rated flow capacity.

To verify that an emergency venting device is adequately sized, an inspector must verify that: 1) The flow rate on the venting device is equal to or greater than the minimum vent flow rate specified on the tank nameplate, and 2) The nipple connecting the tank to the venting device is equal to or greater than the size of the required vent opening and does not exceed one foot in length. UL142 only contemplates a maximum nipple length of one foot, so if a longer nipple is attached to the tank, the vent flow must be calculated by an engineer or other qualified specialist as described above for tanks in buildings.

Question 9: Is it permissible to manifold multiple vents into a single vent pipe?

Answer: Not generally, IFC Chapter 34 and NFPA 30 Chapters 22 and 27 only permit vents to be manifolded for special purposes, such as vapor recovery, vapor conservation and air pollution control. This would preclude manifolding of vents for simple convenience or cost efficiency.

Where manifolded vents are used for special cases, the codes specify minimum criteria to be considered, and for aboveground tanks, the design must contemplate a simultaneous fire exposure of all tanks. This will yield emergency vent flows that are so large that required pipe sizes would be impractical under normal circumstances.

Question 10: What are the testing requirements for normal and emergency vents that bear the UL listing mark?

Answer: UL listed venting devices (and various other tank appurtenances) will indicate that they are listed in accordance with UL 142. However, it is interesting to note that UL 142 is devoid of testing criteria to be used in evaluating these devices. Accordingly, when one sees a UL listing mark on a manufactured venting device, there is no way to readily know what tests that device was subjected to in order to earn its listing. Has the device been subjected to operational cycling, corrosion testing (important for tanks located near the ocean), freeze/thaw cycles, fire exposure...? No published standard documents the minimum requirements.

Instead, for these devices, UL uses unpublished (non-consensus) guidelines that are developed by UL staff, perhaps with selected outside input. The only way to find out what tests were done on a particular device is to ask the device manufacturer for a copy of the UL listing report, which should provide this information.

Access to detailed testing requirements is becoming even more important as alternative fuels that contain alcohol continue to increase in popularity. For tanks containing fuels with significant alcohol content, vent seals must be resistant to alcohol vapors because a flame traveling past a failed seal into a tank's vapor space poses a fire or explosion risk if the vapors in the space are in the flammable range, certainly a possibility with fuels containing alcohol. However, don't assume that UL specifically evaluates pressure-vacuum (P-V) venting devices with respect to their ability to perform as flame arresters...normally, they don't, even though fire codes recognize P-V vents in lieu of flame arresters on flammable and combustible liquid storage tanks. Designers and inspectors need consider whether reviewing the listing report for a particular valve installation is necessary to ensure compatibility of the valve with stored liquids.

UL is beginning the process of developing a standard that will hopefully, at some point, provide published criteria detailing the testing requirements for vents and other tank appurtenances. Given that some of these devices are essential to safety and that they are installed on many tanks, this seems to be an appropriate step. The time frame for completion of that project has not been formally established.

Frozen Tank Vents Probed in Missouri Bulk Plant AST Explosion and Fire

Regulators in Missouri are cautioning aboveground storage tank (AST) owners and managers everywhere to beware of icy weather conditions that could affect the safe operation of vents.

Investigators are examining whether two frozen vents could have led to a bulk-plant fire in Marshall, Mo. – about 80 miles (129 kilometers) east of Kansas City – as a driver was unloading fuel from his truck into a standing 12,000-gallon (45,425-liter) AST.

The source of ignition may have been the idling tank truck, but that question is still under investigation.

The Jan. 7 incident, which led to the death of the truck driver, occurred during a period in which rain, mist and freezing temperatures could have caused the lockup of both the emergency vent and the primary pressure-vacuum vent of the AST.

Investigators believe the frozen vents led to over-pressurization. Without adequate venting, stored hydrocarbons will vaporize during a fire and strain the limits of an atmospheric-rated tank.

After the initial explosion, firefighters spent more than a day extinguishing a pool fire, which at times featured non-insulated tanks with burning product and vent-flame surges of 60 to 100 feet (18.3 to 30.5 meters) in the air, said John Albert, an investigator and trainer with the Missouri Department of Agriculture's Division of Weights and Measures. An elevated water cannon was used to extinguish the flames inside any tank containing ignited fuel.

In the bulk plant's yard, firefighters doused tanks on the trucks with water and foam to prevent additional explosions. The tower truck and three other unstaffed devices were used to spray water on tanks to keep vapor spaces cool.

Investigators discovered a nine-inch split in the bottom of an AST that exploded initially, then again about 18 hours after the start of the blaze.

They are trying to determine the impact of the split on the overall blaze, which ultimately affected seven other nearby tanks – some storing various grades of gasoline and others diesel fuel.

Of the eight non-insulated atmospheric tanks exposed to a pool fire for about 32 hours, only one showed distortion, Albert said.

Fortunately for all involved, two 30,000-gallon (113,562-liter) propane tanks at the bulk-fuel facility were located far enough from the fire to remain unaffected.

About 50,000 gallons (189,271 liters) of gasoline and diesel – including about 8,000 gallons (30,283 liters) in the truck and the rest in the eight standing tanks – caught fire. As vent fires eventually developed, emergency vents on all of the other nearby ASTs operated as designed, Albert said.

Witnesses said the explosions could be heard several miles away, Albert said.

During January, the Division of Weights and Measures received reports of several other tanks in Missouri that experienced frozen vents. However, the Marshall incident was the most dramatic, Albert said.

Tank Talk



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Volume 10, Number 2 March/April 1995

Changes In UST and LUST: The Federal Perspective

Part I in a Series from EPA's
Acting OUST Director, Lisa Lund

by Lisa C. Lund

Like a child poised on the brink of the difficult teenage years, where living life finally starts to mean something, the underground storage tank (UST) program faces a difficult period of crucial decisions. After early successes in the program's infancy, will building on the innovations of the past be enough to ensure success in the day-to-day implementation of the future?

While the program is still young, the time is ripe for a critical look at how the program has progressed. While it is too soon to judge whether the program is a success in achieving any final result, it is valid to look at basic approaches and evaluate whether the set course is a correct one.

There are many ways to take this critical look. This article does not question the underlying philosophy of decentralization of the UST program, or the tenets of flexibility, customer orientation, or constant improvement that go with it. Rather, it focuses on what has happened in the program over the course of time

and ways that the course of the program might be altered to improve the chances for success in implementation.

The UST program attempted to regulate an enormous universe of owners and tanks, both numerically large and tremendously diverse. Any time an action is required for such a large universe, the costs will be high. The costs of the UST program were initially estimated at approximately \$50 billion over the course of

Will building on the innovations of the past be enough to ensure success in the day-to-day implementation of the future?

time. Those estimates to date seem to be on target. But are the costs being incurred truly necessary? Are there better ways of

Continues on page 5

EPA Guide to UST Material Available

The Environmental Protection Agency's office of Underground Storage Tanks (OUST) has published a new edition of its Guide to EPA Materials on Underground Storage Tanks. The free guide is designed for quick reference and contains abstracts, cost and ordering information, and other useful details on nearly 150 UST/LUST materials.

Available materials developed by EPA through July 31, 1994 are included in the 90 page guide which is available from the National Center for Environmental Publications and Information, PO Box 42419, Cincinnati, OH 45242-2419.

Requests can be faxed to NCEPA at 513-891-6685. Please refer to EPA-510-B-94-007.

NFPA's Robert Benedetti Responds to Issues of Code Compliance and Fire Safety

January 5, 1995

To the Editor:

The past issues of *Tank Talk* have focused on fires and explosions involving aboveground fuel storage tanks. The March/April issue included a "question/answer" discussion of the causes of several storage tank fires dating from the 1950s that led to important improvements in NFPA 30, Flammable and Combustible Liquids Code. The August/September issue included Mr. Langford's review of the tank fire and explosion that occurred in Kennedale, TX, in 1968. And, the

November/December issue included two letters in response to Mr. Langford's article, both submitted by individuals who have been active in the development of NFPA 30A, Automotive and Marine Service Station Code, and its requirements for aboveground storage tanks at vehicle refueling operations.

You can add to this litany the tank fire and explosion that occurred in Gadsden, AL, in August, 1976. This incident also occurred at a service station and was similar to the Kennedale incident. A mishap during the filling of two 6,000 gallon aboveground gasoline tanks from a deliv-

ery truck led to a spill fire that directly exposed the truck and the storage tanks. One of the tanks ruptured explosively, killing three fire fighters and injuring 28 others. Key factors in this incident were the lack of any spill control (diking or remote impounding) that would have prevented spilled gasoline from pooling beneath the storage tanks and lack of adequate emergency venting of the tanks. The tanks did have emergency vents in addition to the normal breather vents. But, they were seriously undersized and provided only about one-fourth the flow

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Regional News on Aboveground and Underground Storage Tank Issues

Pennsylvania

A gas well caught fire on December 22, 1994 and melted the wall of a fiber-glass storage tank, spilling salt water and crude oil.

The water and oil were byproducts of natural gas production at a remote well in Young Township, Indiana County.

A well tender discovered the fire at 9 a.m., and about 100 firefighters responded in fire trucks, bulldozers and four-wheel drive vehicles. People who lived and worked near the well saw a large column of black smoke.

There were no injuries or evacuations, and the fire was extinguished late in the afternoon. Emergency management officials said the well is owned by Texas Keystone Inc., an energy company with a Pittsburgh office.

Officials said a considerable amount of oil and water spilled from the 4,000 gallon tank, but they did not have an estimate of how much had leaked.

The state Fish Commission investigated to determine whether the spill had killed or sickened fish in nearby Harper's Run.

Texas

An accidental release of liquid petroleum gas at a bulk storage plant started a blaze that burned for more than an hour before it was controlled by 38 fire fighters.

Apparently, a driver failed to remove the fuel fill hose after filling his tank truck. As the truck moved away from the fill site, it pulled the hose from the electric pump, and liquid petroleum gas was released. The fuel was ignited when wiring that had been severed in the break short-circuited, creating a spark.

Fire fighters used numerous handlines and more than 200,000 gallons of water to extinguish the fire and to protect other aboveground storage tanks. Although they managed to control the fire in just over an hour, fire fighters remained on the scene for another 2 1/2 hours to extinguish spot fires and cool the area.

Two fire fighters received minor injuries during suppression operations. Damage was estimated at \$75,000.

Iowa

Explosions rocked the tiny Lee County town of Houghton, Iowa as fire destroyed a bulk oil plant and knocked out electricity to Houghton and nearby Salem in Henry County.

The blaze, fueled by oil drums of burning motor oil, could be seen for miles. A power outage caused by the explosion and fire in Houghton forced cancellation of classes at the parochial elementary school in Houghton, population 127, and at the public elementary school in Salem, population 453. Power was restored dur-

ing the night, in time for classes the next day.

There were no injuries in the fire, and no evacuations were necessary. The sprawling building housing the Jet Bulk Oil, which sells motor oil in 55-gallon drums and smaller containers, was a total loss. But, amazingly, huge 7,500 gallon storage tanks inside the building did not rupture or burn, according to Gary Thompson, training officer for the Houghton Volunteer Fire Department.

Assistant State Fire Marshal Jerry Corbett said the fire started in the building's electrical service box. No damage estimate was available Wednesday. "I'm sure we're talking six figures, easy, maybe seven," Thompson said.

Thompson said that only oil in 55-gallon drums and smaller containers burned. The explosions that shattered the predawn stillness probably were caused by rupturing drums of motor oil, he said.

Volunteer firefighters from Denmark, Donnellson, St. Paul, Salem and West Point helped Houghton firefighters bring the blaze under control before 7 a.m.

Thompson said one of the first things firefighters did was build two containment dams to prevent leaking motor oil from reaching a nearby creek. "Nothing got through," he said. ☐

Benedetti Responds from page 1

capacity called for by the then-current edition of NFPA 30. In any event, they couldn't function — they had been padlocked shut!

In addition to the deficiencies of the installation, responding fire fighters directed their primary efforts to attacking the spill fire. Little or no effort appears to have been made to apply cooling streams to the tanks themselves. The results were predictable and disastrous.

In the November/December issue, Mel Cosgrove's letter outlined some major provisions of NFPA 30A that apply to aboveground tanks at service stations and showed that these offer protection against the kind of problems evident in the Kennedale and Gadsden incidents. Mr. Frey's letter pointed out that the construction of the Kennedale tank violated some of the most basic design provisions of then-existing codes and had the tank been properly constructed, outfitted, and

installed, it would not have ruptured explosively. Certainly the outcome at Gadsden would have been different, if even the undersized emergency vents were functional and cooling streams had been applied to the tank shells.

These incidents dramatically illustrate the importance of code-compliant design and installation, including proper siting and separation, spill control, and adequately sized emergency vents. Of equal importance is solid inspection and enforcement efforts by local and state authorities to ensure installations do comply with all applicable codes and standards and that the tanks and associated equipment meet accepted design standards and practices, points emphasized by both Mr. Cosgrove and Mr. Frey. I would add that any enforcement official, whether responsible for building, fire, environmental, or public safety rules, needs to know about basic fire prevention and protection measures.

These incidents are often cited as reason to restrict the type of aboveground storage tank assembly that can be used. Certainly they were tragic, leading to deaths, numerous injuries, and destruction of property. But they have, in fact, been shown to be examples of violations of basic fire safety principles and accepted codes and standards extant at the time. Continued development of performance-oriented and technically valid codes and standards can provide users and enforcing officials alike with means to tailor each installation so that risk to the public is minimized, while still providing a cost effective installation that meets the needs of the facility.

Very truly yours,

Robert P. Benedetti

Senior Flammable Liquids Engineer
National Fire Protection Association

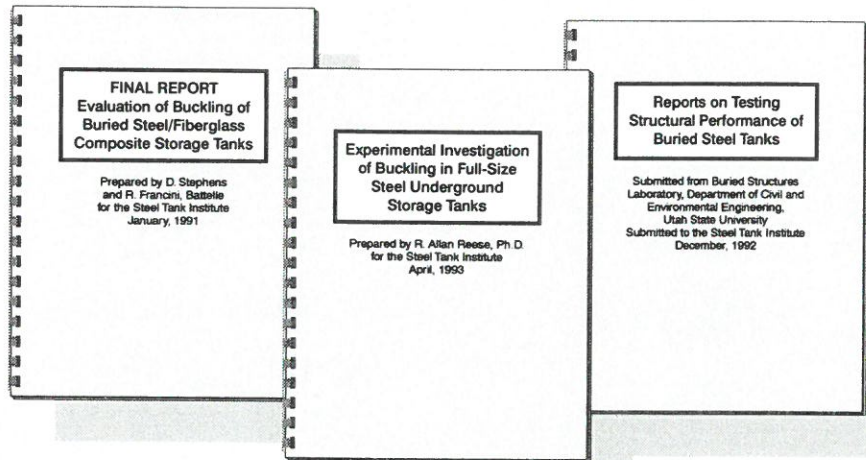
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Allan Reese Presents Buckling Study At ASME Conference

Allan Reese, president of Ace Tank & Equipment in Seattle, Washington, presented a paper titled "Experimental Investigation of Buckling in Full-Size Steel Underground Storage Tanks" on June 20, 1994, at the American Society of Mechanical Engineers (ASME) Pressure Vessels & Piping Conference in Minneapolis, Minnesota. This paper was based on work sponsored by the Steel Tank Institute. Key conclusions given by Dr. Reese from the study included:

- 1) Experimentally measured buckling pressures followed textbook equations for buckling pressures of vessels exposed to uniform external pressure. The buckling pressures were found to be proportional to the 2.55 power of the shell thickness, in excellent agreement with the theoretical value of 2.50.
- 2) Tanks with stiffer shell-to-shell weld joints, such as joggle joints with continuous internal welding, failed at buckling pressures up to 30 percent higher than less stiff joints, such as butt welded joints.
- 3) Internal stiffeners can increase the resistance to buckling considerably.



The study by Allan Reese is the third in three years on the issue of buckling of steel underground storage tanks, the others being done by Battelle and Utah State University.

- 4) A bare steel 4,000 gallon tank, fabricated per UL 1746, reduced wall thickness specification, failed below 3.0 pounds per square inch (psi). Because the pressure at the bottom of these tanks can exceed 6 psi when they are buried, backfill is necessary
- 5) Experimentally, a 0.10-inch thick fiberglass reinforced plastic coating (cladding) on the outside of a 10-gauge, 4,000 gallon tank increased the buckling pressure about 5 percent compared to an unclad tank.

to prevent these tanks from collapsing.

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Devastating Explosion in Texas Relived

By Mason Lankford

In retrospect, we still find it hard to believe. We know for sure that a single 10,000 gallon aboveground gasoline tank catching on fire and exploding can cause the loss of three close friends. In addition, it can cause a total of 57 fire department personnel and citizens standing by to be injured. And we know it occurred on a tragic afternoon in the summer of 1968.

The incident took place on July 31, 1968, in a rural area between the cities of Kennedale and Mansfield, Texas, south-east of Fort Worth on U.S. Highway 287.

As the investigating officer, I was able to gather information and piece together the following sequence of events which led up to the massive explosion. I was personally grieved by the fact that the fatalities included Fire Chief Harry Blissard of Mansfield, Shirley Clyde Copeland of Mansfield and TV Newsman Steve Perringer, all long-time friends.

How It Started

To set the stage, a 7,000 gallon tank truck, with a power take-off transfer pump, had been assigned to go to the Red Ball station south of Kennedale and

outside of their city limits, to fill an aboveground tank. There was a baffle in the tank, dividing it into 7,000 gallons at one end and 3,000 gallons at the opposite end. The truck operator started the filling process by filling the 3,000 gallon end with ethyl gasoline. He then changed his hose and started filling the regular gasoline portion of the tank.

Since the temperature was 104 degrees in the shade, he left the side of the truck and went to the cashier's stand of the service station and bought a soft drink,

Continues on page 2

Explosion Relived from page 1

leaving the truck pump in gear and letting it continue to fill the tank. With his back to the truck as he talked with cashier, he was interrupted by a person who came to purchase some gasoline for his car, telling him that the gasoline was overflowing from the tank through the vent valve.

He immediately went to the truck and took the pump out of gear, leaving the diesel engine running. He then got a garden hose and started washing the gasoline down the slope of the driveway.

The ground around the station was made a drivable surface by pulling the tabs off of asphalt shingles, placing them on the ground and then compressing them in place by driving heavy trucks and cars over the driveway area.

The gasoline, by its nature, rapidly penetrated into and under the surface of the shingles. This single fact caused the fire to look much more dense and hazardous than it really was.

With the washing down of the gasoline spill area, the fumes and vapors spread eastward, under the tank truck and toward the truck cab and engine. Approximately three minutes after cutting off the supply of gasoline, the vapors reached the engine area of the truck and were ignited.

The later investigation found that the ignition point was the alternator of the truck tractor. Once there was ignition, the three people in the area immediately ran from the scene to get as far away as possible.

Emergency Personnel Respond

Residents in the area saw the smoke arise and called the Kennedale Volunteer Fire Department. Kennedale in turn radioed Mansfield for their mutual-aid support. Eventually there were over 25 fire units from nine fire departments responding to a request for mutual-aid at the explosion scene.

The tank was a shop-built skid tank, common at self-service stations of the time. However, it had faults that indicate that the builder did not know what he was doing or what the codes and standards of the time dictated. At the 7,000 gallon end of the

tank there was a 2-inch vent, which should have been at least 4-inches, through which the overflow discharged. At the opposite 3,000 gallon end there was NO vent. With the 3,000 gallon end full, and the 7,000 gallon end overflowing, the gasoline came out of the vent and ran over the top of the tank, down the sides, under the tank, and onto the apron area by and under the tank truck.

When the first unit of the Kennedale Fire Department arrived, with a single member driving the unit, the driver drove up to the scene, turned the truck around and went one-quarter mile down the road. He turned around again and parked along the shoulder of the road.

**“At the opposite
3,000 gallon
end there
was NO
(emergency)
vent.”**

Citizens as well as members of the Tarrant County Sheriff's Patrol asked him why he did not go ahead and put his 500 gallons of water on the fire and control what he could until assistance arrived from both Kennedale and Mansfield. He replied, “There was going to be a hell of an explosion” and did nothing further.

There was a standard fire hydrant on an 8-inch circulating main less than 150 feet from the fire scene. During this time (15 to 18 minutes) the fire was building up, causing the fuel in the 7,000 gallon end of the tank to boil over and reach what is called a “percolating” condition, with the tank jumping up and down on the skids.

Meanwhile, the Mansfield Fire Department arrived at the opposite end of the fire scene and was laying out their hose, preparing to attack the fire. Chief Blissard asked his mem-

bers to delay the water attack and he called for a one and a half inch in-line foam eductor and 30 gallons of foam to be brought to the scene from the fire station in Mansfield. This would take another 12 to 15 minutes to arrive.

The Explosion

But before the foam and nozzle arrived, it happened. With the tank truck beside it burning and melting down its aluminum shell, the skid tank suddenly exploded with a terrific roar and blew out the west end of the tank and the divider baffle. The tank started moving on its skids and rapidly went through the cashier's stand some 25 feet from the east end of the tank and another 50 feet, where it hit the side of a house trailer that was the residence of the manager of the station.

The force of the forward motion of the tank was so great that it wrapped the frame of the trailer around the tank and molded the frame into a single large U-shape around the leading edge of the tank.

With the forward motion, the blast of the discharge at the rear end of the tank exploded and propelled itself by Chief Harry Blissard and Fireman Shirley Clyde Copeland. They were seriously burned and immediately transported to the John Peter Smith Hospital in Fort Worth. They were later transferred to the burn center at Parkland Memorial Hospital in Dallas. Chief Blissard and Fireman Copeland passed away the next day.

Steve Perring, leading news photographer for CBS-TV, Channel 4 in Dallas, was always at the scene when something was happening. While in school, he would always ride his bicycle to school. When the fire siren for the River Oaks Volunteer Fire Department sounded, he would run from class and go to the emergency scene, a true devotee, to find out what was happening. Steve put that devotion into his professional job.

At the time of the blast, Steve was standing on the porch of the house just west of the tank location. The house took a solid blast from the

Continues on page 3

Explosion Relived from page 2

end of the tank as it took off like a rocket. The end of the tank came off and flew some 100 feet through the air, hitting a large oak tree some 12 to 15 feet above the ground. The divider baffle blew out, hit a tree and rolled away from the scene. Steve passed away two days later.

Today, the "Steve Perringer Award" is given annually to the outstanding TV news person of the Fort Worth/Dallas area. Each year, the members of the news profession pay their respects to Steve and remind all of the newcomers of the exploits of one who preceded them.

Later inspection of the end of the tank showed that the weld was actually a very thin strip joining the tank and the end. Experts said that the weld should not have passed any kind of test. Inspection also found that the baffle was not welded the entire perimeter of the tank but was only spot-welded about every 18 to 24 inches.

Lessons Learned

The trauma of the families and friends of these three individuals will never heal. Therefore, it is up to us to remain dedicated to insure that this type of incident never occur again.

Amazingly, in an area some 125 miles southwest of Fort Worth, a similar incident occurred within 4 weeks. Luckily there was not a loss of lives. There was major damage to the gasoline station and the transport truck.

Let us now evaluate each step of the Kennedale incident.

In the training process for the Fireman, all were instructed to initially attack the fire with the water that was available and attempt to hold the situation until additional help could be summoned. This was not done. This method is still being taught today and the Kennedale example is explained to all personnel.

In the training process, they were also instructed to never stand by and let an area burn, much less a major incident such as this. This was not done. Aggressive attack to the extent of available resources is mandated. When resources are expended or conditions warrant, they are to back off a safe distance so that fire personnel will not become the fire victims.

In Texas, there was a ground swell of support to do away with all aboveground

tanks and put them underground where a repeat of this incident could not happen. The Texas legislature

"Inspection of the end of the tank showed that the weld was actually a very thin strip joining the tank and the end. Experts said that the weld should not have passed any kind of test."

passed a law which required that tanks at retail stations be underground. Unfortunately, the law still allowed privately owned tanks to remain above ground, thus the potential problems for fire service personnel still exist.

Today, because of regulations from the Environmental Protection Agency and the Water Quality Board, there is a trend towards moving tanks aboveground.

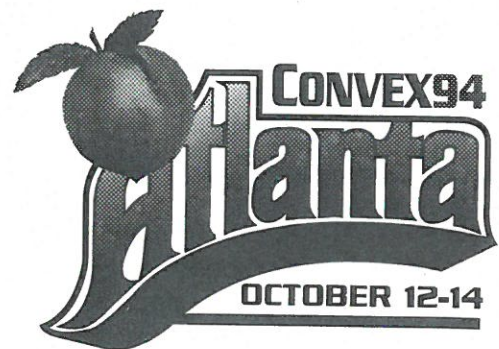
I do not know what the future holds for the safety aspects of gasoline storage tanks. But whatever the approach taken, the interests of the fire service and emergency personnel must remain uppermost in mind. The legal and code requirements should insure that all safety provisions known to man be included in the standard requirements.

With this accomplished, no other person will ever have to go through the mental anguish and heartfelt pain that I have faced since July 31, 1968. STI

Mason Lankford is a consultant on public safety communications, fire department administration and operations, and emergency management. Mr. Lankford resides in Ft. Worth, Texas.

**PEI Convex Show
Right Around the Corner**

The Steel Tank Association, a cooperative venture owned by members of Steel Tank Institute, will be exhibiting at the Petroleum Equipment Institute's annual Convention & Trade Show in Atlanta, Georgia, scheduled for October 12-14, 1994. Please stop by STA Booth #1433-1532.



**GEORGIA WORLD CONGRESS CENTER
ATLANTA, GEORGIA**

Fireguard™ Now UL listed to Meet UFC “Protected Tank” Requirements

The Fireguard aboveground storage tank introduced by Steel Tank Institute (STI) members, is now UL 2085 listed to meet Uniform Fire Code “protected tank” appendix II-F requirements. Fireguard™ also meets requirements for 2-hour fire protection of the 1993 NFPA 30A, the 1993 B.O.C.A. National Fire Prevention Code and the SBCCI Standard Fire Prevention Code.

During the latest testing, “Fireguard’s primary tank temperature rose only an average of 170 degrees Fahrenheit, out of the maximum average rise of 260 degrees allowed by UL,” according to STI’s Technical Manager, Lorri Grainawi. Lightweight and porous insulation material in the interstice — the monitorable space between the two steel walls of the tank — provides Fireguard™ with thermal resistance. The outer steel wall provides UL listed, impervious secondary containment for 110% of product stored. Fireguard™ is now qualified to bear the UL label, “Insulated Secondary Containment Aboveground Tank for Flammable Liquids — Protected Type,” and is always sold as a double wall tank.

Grainawi added that “Fireguard™ met the rigorous test criteria of the Uniform Fire Code such as the Ballistics test, Impact test, Hose Stream test, and Furnace test.”

Test Details

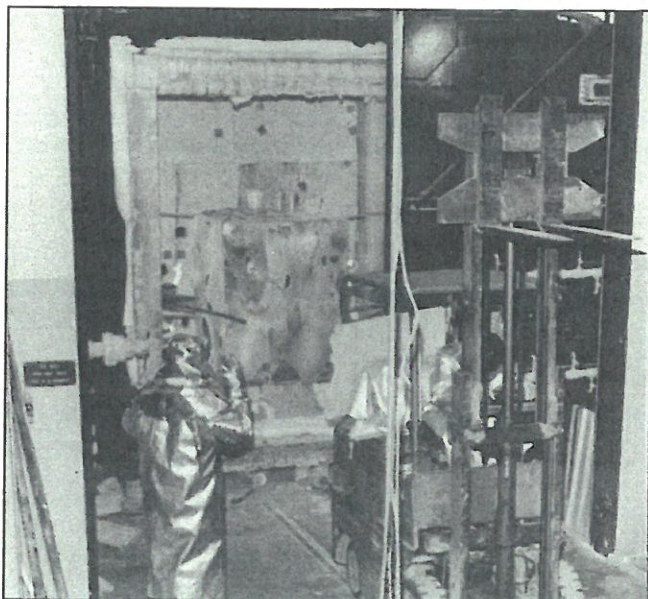
The ballistics test requires that the tank be shot at five times with a 150 grain M-2 ball ammunition, having a muzzle velocity of 2700 feet per second, fired from a .30 caliber rifle at a distance of 100 feet. The pass/fail criteria is that there shall be no penetration of the primary tank. Even though the projectile test is optional under the Uniform Fire Code, Fireguard™ was still subjected to this test.

The impact test is to be conducted only when it is intended to install the tank without protective guard posts. Because Steel Tank Institute members do not feel this practice is safe, the installation instructions for the Fireguard™ tank require that the tank be installed with some means of protection. For added security, the impact test was conducted on Fireguard™ anyway. The tests consisted of hitting the tank with a 12,000 pound weight moving at 10 mph. The weight is to hit the tank 18 inches off the ground, in a one square foot area, in the section of the tank deemed to be the most vulnerable. The pass/fail criteria is that at the end of the test, the primary tank does not leak.

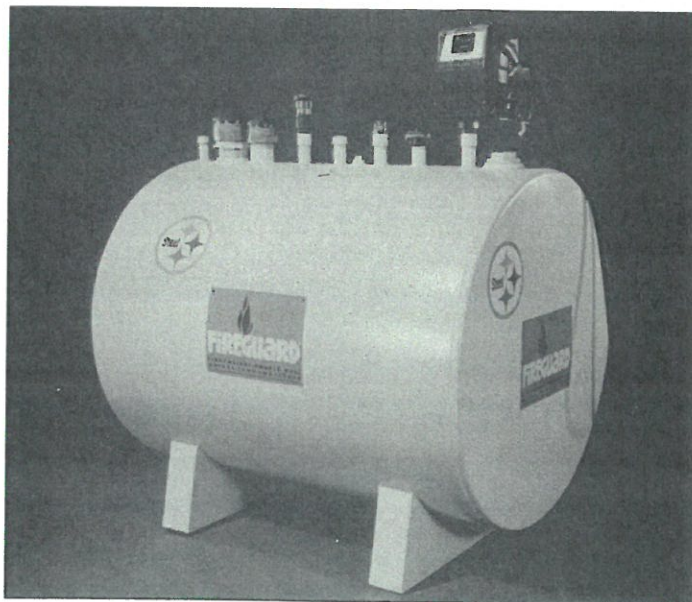
The furnace test requires that a tank with the greatest surface area to volume ratio be placed within a 2000 degree furnace for two hours, to simulate a pool fire test. The smallest tank (in this case a 186

gallon model) is usually decided to be representative of one that may be most vulnerable in a worst case fire scenario. Therefore, this test proves the safety of all tank sizes. After two hours, the temperature of the primary tank cannot exceed an average temperature rise of 260° F. No single thermocouple can exceed 400° F. The Uniform Fire Code chose 400° as a maximum temperature to prevent the auto ignition of product inside the tank. Heptane, the main constituent of gasoline, has an ignition temperature listed at 399° by NFPA 329M. Immediately after the test, the tank is subjected to a hose stream test, which consists of hitting the tank with a stream of water for at least 2 1/2 minutes. Again, the primary tank is not to leak at the end of the test. Depending upon the tank construction, UL may require other tests as well.

Fireguard™ also passed tests that demonstrate unique product characteristics as required by UL, such as the ability to monitor fluids in the interstitial space. In addition, Fireguard™ was subjected to a pool fire test to prove its emergency venting capabilities of the secondary tank. The Fireguard™ aboveground storage tank is available in both cylindrical and rectangular designs, and is offered in a wide range of capacities from 186 up to 50,000 gallons. STI



Two-hour furnace test.



The innovative design of the UL 2085 listed Fireguard™ aboveground storage tank includes putting the lightweight, porous insulation material into the interstitial space (i.e., the space between the two steel tank walls).

ASK THE PRO

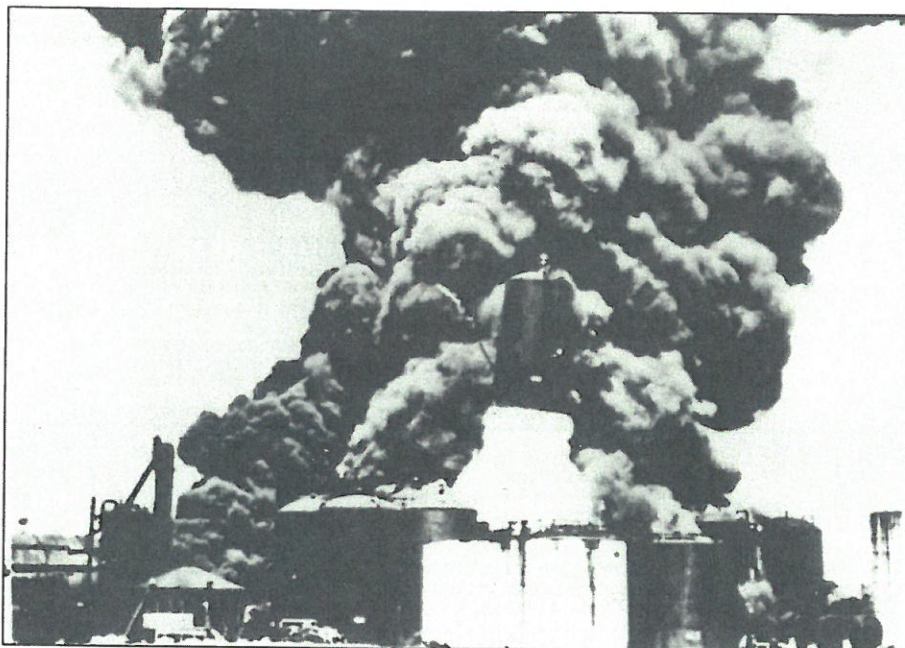
NFPA Documents Causes of AST Fires

Editor's Note: The following feature article is in "Question and Answer" format and includes responses from Robert P. Benedetti, Senior Flammable Liquids Engineer/Senior Chemical Engineer, National Fire Protection Association, clarifying the causes of several well-known aboveground storage tank fires.

QUESTION I understand that the National Fire Protection Association (NFPA) has documented causes of fires involving aboveground storage tanks (ASTs). What are some of the common elements of these fires?

ANSWER Neglecting fires ignited by lightning or electrostatic discharge — and these are more a factor in large terminal and refinery tanks — the common element is the release of a flammable liquid (i.e., gasoline) due to an overfill or a break in the piping system. Once the fuel is out in the open and evolving vapors, then ignition is possible from any number of sources.

The key is to prevent the release from occurring at all and certain requirements in both NFPA 30, Flammable and Combustible Liquids Code, and NFPA 30A, Automotive and Marine Service Station Code, are directed toward this.



Failure to provide proper emergency relief venting can cause tanks to rocket great distances or explode violently as this aboveground tank from a bulk facility chemical plant did. Photo courtesy of NFPA.

QUESTION Two aboveground storage tank fires in particular are referenced when it comes to ASTs used to store pe-

troleum liquids. Can you tell us what you know?

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Strength of Steel Tanks Tested

Since the first Edition of Underwriters Laboratories' Standard for Steel Underground Storage Tanks for Flammable and Combustible Liquids was published in October 1925, literally hundreds of thousands of steel underground storage tanks have been installed.

Remarkably, the history of structural problems created by this tank design have been virtually non-existent, a fact commonly marketed within the industry, that being the "strength of steel." The steel industry has always been quite proud of its performance, not only with tanks, but

also with other structural steel components.

Low carbon steel has a tremendous amount of ductility. Ductility is what allows the steel tank to adjust, without cracking, to various geotechnical forces, such as from soil loads or hydrostatic forces from high water tables. This property is what differentiates steel tanks from fiberglass reinforced plastic (FRP) tanks, which are more brittle. One measure of ductility is the amount of elongation which a material can sustain before fracturing. The elongation of mild steel is

about 15 times greater than the elongation of fiberglass reinforced plastic.

Whereas elongation may determine whether or not a tank will leak after it has buckled, stiffness will determine a tank's resistance to buckling. Tank geometry and the material used to construct the tank have a bearing on tank stiffness. For instance, modulus of elasticity is an engineering term used to describe a material's physical properties — in this case, the ratio of stress a material can absorb for a given strain. Steel used in underground

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ANSWER The two incidents usually referred to occurred in the 1950s. The first happened in July 1956 at Shamrock Oil & Gas Corporation near Amarillo, TX. In this incident, a burning spherical storage vessel failed catastrophically, killing 19 fire fighters. Flames issuing from the vessel's vent impinged on the vessel shell, weakening it to the point where it failed from overpressure.

The second incident occurred in August 1959 in Kansas City, KS. In this case, a spill fire at a small fuel distributor/service station led to the rupture of four horizontal storage tanks. One of these tanks ruptured violently and rocketed. The fire ball from the sudden release of the tank's contents killed five and injured 64 people.

Another, less well-known, incident happened in May 1956 in Maryland. This fire and explosion incident was almost identical to the one in Kansas City and killed two fire fighters.

These incidents tragically demonstrated the importance of adequately sized and properly arranged emergency relief venting for aboveground tanks. In all three cases, the design of the vents allowed burning fuel vapors to impinge directly on the bare, unwetted top part of the tank shell. This led to gradual weakening of the shell.

Compounding the problem, it is believed that none of these tanks had sufficient emergency venting capacity. They all had adequately sized breather vents, but they probably didn't have the necessary additional venting to relieve the internal pressure generated by boiling of the tank contents. So, you had gradual weakening of the tank shell at the same time that internal pressure was increasing. Without massive application of hose streams to cool the tanks, failure was inevitable.

As a result of these fires, NFPA 30 was amended to require installing tank vents so that overheating of the tank shell did not occur. In addition, more attention was paid to providing additional emergency venting capacity, where the normal vents were insufficient.

QUESTION Since 1984, NFPA 30A, Automotive and Marine Service Station Code, has included language that allows aboveground tanks for fuel dispensing at commercial, manufacturing, governmental and industrial facilities. Has NFPA heard of any fire safety incidents involving tanks that have been properly installed according to this language?

ANSWER The language to which you refer is Section 9-3.5 of NFPA 30A and, no, we haven't heard of any fire incidents involving such installations. But you have to understand that ASTs weren't commonly used until recently. With the implementation of the U.S. Environmental Protection Agency's underground storage tank

**“Compounding
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venting capacity.”**

rules, many fleet-type operators have taken advantage of Section 9-3.5 to abandon their underground tanks in favor of aboveground systems. I expect more such systems to come into use and NFPA's Technical Committee on Automotive and Marine Service Stations will study any incident that might happen to determine if there are any deficiencies in Section 9-3.5 that need to be corrected.

Let me share with you some of the history of Section 9-3.5. It applies to the traditional fleet operator. In other words, the person or entity that owns or operates the tank and dispenser

system, owns and operates the vehicles that are refueled. It originally appeared as Section 8-3.6 of the 1984 edition of NFPA 30A, which was the first edition and at that time was under the jurisdiction of the Committee on Flammable and Combustible Liquids, whose primary responsibility is NFPA 30.

The concept originated with a proposal to allow the use of a “package-system” design: a skid-mounted tank, an integral spill pan that served as a containment dike, an attached dispenser and all necessary piping and electrical fittings. My recollection was that it was intended to be easily moved and would have had obvious value at large construction or earth-moving projects.

Because NFPA codes and standards have to be performance-oriented, the language was written to present a basic set of requirements that could be met by any appropriate design. It allows a 6,000 gallon aboveground tank to serve a single dispenser. The tank must be listed or approved for aboveground use and must be designed and installed in accordance with NFPA 30. The system also must have suitable safeguards against collision damage, overflow and spillage. Most important of all, the authority having jurisdiction, usually the local or state fire marshal, must approve the installation.

QUESTION The 1993 edition of NFPA 30A was released last August and contains provisions that allow the use of aboveground storage tanks at any automotive service station. What were some of the considerations in developing these provisions and what are some of the key elements?

ANSWER During the development of the 1990 edition of NFPA 30A, the Technical Committee on Automotive and Marine Service Stations was asked, by user interests and state and local fire officials, to consider developing requirements for the use of aboveground storage tanks at all service stations and in capacities exceeding the 6,000 gallons allowed by 9-3.5. The impetus for this was the cost of upgrading older underground storage systems to meet EPA's underground tank rules and the difficulty many smaller independent service station owners and operators

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were experiencing in obtaining pollution liability insurance.

The Technical Committee was understandably somewhat reluctant to pursue this, since underground storage systems have proven to be the most fire safe means for storing fuel at service stations. Underground tanks are just not subject to exposure fires or internal explosions and this fact needs to be kept in mind. And, with the new generation of underground tanks and tank fittings now available, underground storage systems can provide a very high level of environmental protection. Nevertheless, some state and local laws were rewritten to allow the use of aboveground tanks, but with no technical guidance on how to achieve a fire safe installation.

In 1989, the Technical Committee formed a Task Group to study the problem and a Tentative Interim Amendment that established requirements for aboveground tanks at any service station was adopted to the 1990 edition of NFPA 30A. As work began on the 1993 edition of NFPA 30A, the Task Group refined the requirements to address certain specific issues and recognize the new generation of fire resistant tanks. Section 2-4 of NFPA 30A contains these requirements.

The primary considerations in developing these requirements were limiting the quantity of fuel stored to a reasonable maximum and separating the storage tanks from the refueling area (i.e., the area immediately accessible to the public).

The maximum aggregate aboveground storage capacity is 40,000 gallons and individual tanks are limited to 12,000 gallon capacities. These capacities were chosen based on typical underground systems now in use. The maximum individual capacity accommodates the largest delivery of a single product grade that can be expected. The maximum aggregate capacity allows the flexibility needed to offer a full range of fuel products, typically three grades of gasoline, plus diesel fuel.

To maintain adequate separation,

each tank must be at least 50 feet from any dispenser, any important building on the service station property, and the near side of any public way. In addition, each tank must also be set back 100 feet from the property line. You can see that the Technical Committee didn't intend these installations for urban areas; these numbers translate to a minimum property size of 200 feet by 200 feet, almost an acre. In every case, there must be control of spillage, should an overflow or a piping break occur, and emergency relief venting to prevent catastrophic failure, should the tanks be impacted by an exposure fire.

The Technical Committee balanced the tank capacities with required separation distances and other fire safety features to achieve a reasonable degree of confidence that the tanks would not be involved in a fire. The Technical Committee did allow a 50 percent reduction in the separation distances for fire resistant tanks and for vaulted tanks.

Fire resistant tanks are those having two hours fire resistance, as tested, and are covered in 2-4.5 of NFPA 30A. These can be insulated or concrete-encased tanks. Vaulted tanks are traditional aboveground tanks that are located in an above-grade or below-grade vault or enclosure. These are covered separately in 2-4.4 of NFPA 30A. It is important to understand that some new-technology tanks that use the word "vault" in their trade name are not considered vaulted tanks by NFPA 30A.

There are many other specific requirements imposed by NFPA 30A. For example, tanks that are not located in a vault must be surrounded by a fence and provided with collision protection. And, there are a number of piping-related and bulk delivery-related requirements that are peculiar to these installations.

All of these requirements are directed at maintaining the integrity of the fuel storage system, isolating the fuel storage from the service station patron and maintaining a safe separation between the fuel tanks and adjacent property and buildings.

In my opinion, it is important to understand that installations meeting Section 2-4 might not provide the same

degree of fire safety as does an underground installation. For example, aboveground tanks are more susceptible to changes in ambient temperature, so they will breathe in and out to a much greater extent than will underground tanks.

One final note: It isn't always recognized among the environmental protection community that there are differences in the release modes of underground and aboveground tanks. Underground tanks release liquid when the tank shell corrodes (i.e., old unprotected USTs) or cracks or when the piping system develops a leak. Double-shell tanks, double-wall piping systems, and other special piping components have evolved to address these situations. A properly installed underground storage system, one that meets NFPA 30 and the regulations of the U.S. Environmental Protection Agency (EPA), provides a very high degree of environmental protection coupled with, essentially, total fire safety.

Spills from aboveground tanks are typically overflow events (i.e., human error) or piping failures. Double-wall piping can provide some protection, but isn't commonly used because proper preventive maintenance will usually spot a problem before it gets to be serious. Double-wall tanks might or might not have the capability to contain a release from an overflow. There is sometimes a misconception that a "secondary containment" type aboveground tank, by itself, meets the spill control provisions of NFPA 30. This is not true. NFPA 30 now includes some special requirements that these tanks must meet before they can be considered to be equivalent to a diked installation. Refer to Exception No. 2 of Paragraph 2-3.4.1 of NFPA 30 for these special requirements. ■

Mr. Robert P. Benedetti has been a senior flammable liquids engineer and senior chemical engineer for National Fire Protection Association since 1974 and is closely involved in the history and development of NFPA 30 and its related standards.

Tank Talk

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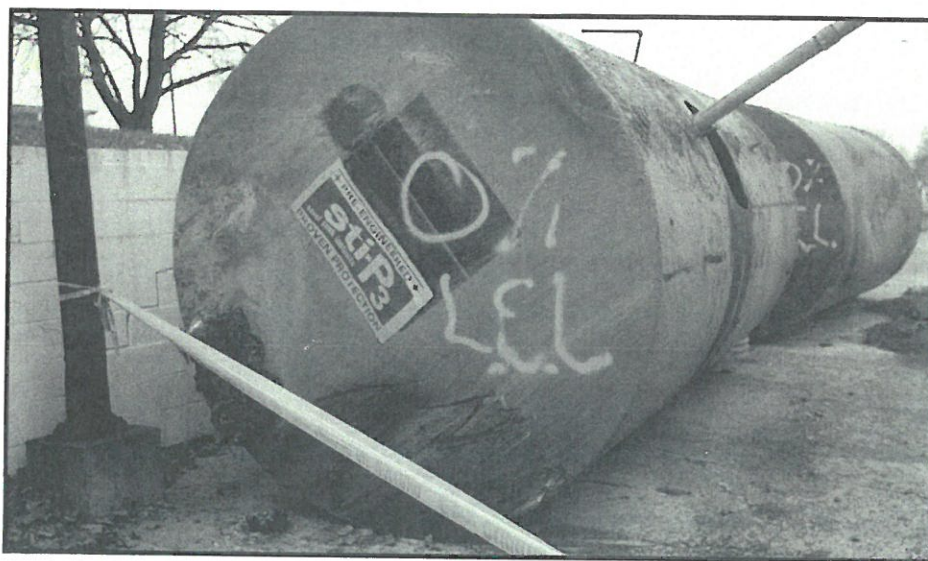
Performance Prevails for 20-Year-Old Steel sti-P₃® Tanks

In 1972, Kennedy Tank & Manufacturing Company, Inc. built three single wall sti-P₃® underground storage tanks (USTs) for its subsidiary, Stafco, to sell to a major oil company. These three tanks were installed in a commercial section of Warsaw, Ind.

In November 1992, the property where the gas station once stood was excavated so that existing tanks could be removed and the facility converted to a car wash/restaurant. Upon removal, the 20-year-old sti-P₃® USTs were documented to be in excellent condition.

The 12,000-gallon and two 6,000-gallon sti-P₃® tanks were solid. The coal-tar epoxy coating exhibited no signs of peeling. Wired-on magnesium anodes remained intact. While the tanks did get scratched and dented during excavation, they were documented to be in exceptional shape.

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This is one of three sti-P₃® underground steel storage tanks that was excavated and found to be in excellent condition after being buried for twenty years.

Fire Code Committees Adopting New AST Technologies

By Wayne B. Geyer

America's leading fire codes are paving the way for the use of new aboveground storage tank (AST) technologies in dispensing motor fuels.

Actions taken last month by fire code officials at separate national conferences have increased the fuel storage options for businesses that need to store significant quantities of petroleum products.

Recognizing Safety Features

Among other new technologies for smaller capacity vessels, fire-code officials are recognizing the safety features included in aboveground storage tank designs that employ secondary containment. That recognition was spurred by the growth in products such as double-wall design ASTs, and a single-wall steel tank in a steel dike. These are probably the most frequently installed aboveground tanks in capacities of 30,000 gallons and under.

Distinct committees from the National

Fire Protection Association (NFPA) and the Uniform Fire Code (UFC) accepted revised code language in December that creates greater opportunity to dispense motor fuels from aboveground storage tanks. The UFC is published by the International Fire Code Institute.

NFPA 30 is one code document from the National Fire Protection Association, which deals with ASTs from the perspective of storage and handling of all flammable and combustible liquids. Though related, NFPA 30A provides a distinct approach from NFPA 30. The NFPA 30A code governs the dispensing of motor fuels for vehicles.

Changing AST Views

The actions of the NFPA and UFC committees will significantly change the way that local fire officials view the installation and usage of aboveground tanks. Many fire inspectors will welcome the flexibility that these revisions provide in interpreting safety questions. But,

some may resist the code changes because of personal preference for traditional fuel storage options, such as underground tank systems.

Increasing demand for aboveground storage tanks followed the 1988 release of federal environmental regulations for underground storage systems, and the subsequent development of state regulatory programs. Many fleet-facility and service station operators—especially in less-populated areas—questioned why improved technologies for aboveground storage were restricted by the national fire codes. Underground tank owners were experiencing many problems related to federal and state financial responsibility requirements.

Enacting New Laws

NFPA and UFC began in 1990 to address the new aboveground storage demand as legislators in some states reacted to pressures from underground storage tank owners. Some legislatures

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FIRE CODES

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enacted laws that allowed greater usage of such tanks for storage and dispensing of motor fuels. Some state laws bypassed the historic authority of fire officials in regulating flammable and combustible liquids.

Here are highlights of the code changes approved independently in December by the NFPA 30 committee, the NFPA 30A committee and the International Fire Code Institute's code development committee.

NFPA 30

Many forms of secondary containment for factory fabricated aboveground tanks have surfaced in recent years, but the NFPA 30 language does not appear to benefit any particular technology.

NFPA 30 committee members agreed with the need to recognize the spill-control features included in double-wall aboveground storage tanks for fire safety. In case of fire, the committee's decisions require emergency venting as a double-wall tank feature to prevent the build-up of explosive vapor pressure within the interstice—or space between the inner and outer walls.

Emergency Venting

Emergency venting is one of the true key measures to a safe operation of an AST. Flammable liquids produce vapors which are normally vented out of the tank through the vent pipe. These tanks are commonly designed and fabricated for atmospheric pressures. In a fire, vapors are produced more rapidly due to the higher temperatures that develop. If the tank cannot dispel the vapors quickly enough, a pressure will begin to build up within the tank.

Hence, fire codes and standards for tank construction, i.e., UL 142, mandate an additional vent that will operate only under emergency conditions. With such a vent, the chances of a tank explosion due to high pressure are eliminated.

The committee limited the maximum capacity of a secondary containment aboveground tank to 12,000 gallons. This coincides with the NFPA 30A proposal. Other mandates include overflow prevention, collision barriers and anti-siphon piping connections above the tank's liquid level.

Proposed NFPA 30 Language

If accepted, the new NFPA 30 proposed language will incorporate several very important limitations on when integral secondary containment is acceptable. Amendments will be added as an exception to NFPA 30, paragraph 2-3.3.1, which covers traditional AST spillage control for public safety from fires and explosions, such as with diking and remote impounding.

Diking can be made with steel, concrete or earthen materials of construction. Remote impounding is the drainage of liquids to a remote location away from tanks, buildings and property lines, where public safety would not be at risk.

These two methods of spill control were originally placed within the code for large field erected tanks, but authorities having jurisdiction have used it to regulate all sizes of tanks, as the size of the AST was not differentiated within the code.

Here is the anticipated NFPA 30 language that will be voted upon in May 1993 by the NFPA Committee.

2-3.3.1 Facilities shall be provided so that any accidental discharge of any Class I, II or IIIA liquids will be prevented from endangering important facilities, and adjoining properties, or reaching waterways, as provided for in 2-3.3.2 (remote impounding) or 2-3.3.3 (diking).

Exception 1: Tanks storing Class IIIB liquids do not require special drainage or diking provisions for fire protection purposes.

Exception 2: Secondary containment-type tanks need not meet the requirements of this Subsection if all of the following conditions are met:

- a) Tank capacity shall not exceed 12,000 gallons.
- b) All piping connections to the tank shall be made above the normal liquid level.
- c) Means shall be provided to prevent the release of liquid from the tank by siphon flow.
- d) Means shall be provided for determining the level of liquid in the tank. This means shall be accessible to the delivery operator.
- e) Means shall be provided to prevent overflow by sounding an alarm when the liquid level in the tank reaches 90% of capacity and by automatically stopping delivery of liquid to the tank when the liquid level in the tank reaches 95% of capacity.
- f) Spacing between adjacent tanks shall be not less than 3 feet.
- g) The tank shall be capable of resisting damage from the impact of a motor vehicle or suitable collision barriers shall be provided.
- h) Where the interstitial space is enclosed, it shall be provided with emergency venting in accordance with 2-3.6.

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Questions Answered about Proposed AST Legislation

By Kristin King

Editor's Note: The Safe Aboveground Storage Tank Act of 1993 was introduced by U.S. Rep. James Moran (D-VA) and U.S. Sen. Charles Robb (D-VA) as H.R. 1360 and S. 588, respectively, on March 16, 1993, and has not yet reached the committee level on Capitol Hill.

What follows in interview format are answers to questions regarding the Safe Aboveground Storage Tank Act of 1993 provided by Kristin King, a legislative assistant to Congressman Moran who covers environmental, energy, agricultural and women's issues.

What events took place which motivated Rep. Moran to develop the Safe Aboveground Storage Tank Act of 1993?

Unfortunately all of us in the Washington, DC area have become intimately aware of problems with a leaking tank farm involving field-erected aboveground storage tanks (ASTs) located only 20 miles south of the Capitol.

The tank farm, owned by Star Enterprise/Texaco, leaked over 200,000 gallons of petroleum product over the past several years. The petroleum product from the tank farm traveled through the groundwater and spread underneath nearby homes. Vapors from the petroleum became so



Federal legislation introduced in March contains a variety of provisions for aboveground storage tanks such as registration fees, leak detection and monitoring, leak prevention, notification, registration fees, corrective action orders and inspections.

strong that many residents had to have vapor detection systems installed. Throughout the course of this leak, many fire officials ordered homes evacuated due to the threat of explosion. The homes in these communities, some of which were once valued at half a million dollars,

could not be given away today. Star Enterprise, by the time all payments have been made to compensate homeowners for health expenses and other costs, will pay in excess of \$200 million dollars. This does not even count the extensive cleanup

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Emergency Relief Vents Provide Safety

By Charles Glab

Emergency relief venting is a critical component in the quest to ensure safe aboveground storage of flammable liquids. The purpose of this article is to present some of the fundamentals on emergency relief venting for shop-fabricated aboveground storage tanks (ASTs).

Shop-Fabricated ASTs

Shop-fabricated ASTs are tanks built in a factory, transported to a site and installed.

These tanks are typically fewer than 50,000 gallons capacity and are 12 feet or less in diameter. The other type of aboveground tank, field-erected tanks, are built in the field and normally quite a bit larger. Emergency relief venting on large field-erected tanks involves different principles that are not addressed in this article.

Emergency Vent Basics

An emergency vent for a shop-fabricated tank is usually a separate

component produced by someone other than the tank manufacturer to be brought in and installed on the tank. Depending upon the vent design and the arrangements made, the vent is either installed at the factory or in the field. Either way, it eventually becomes an integral part of the storage system. The function of an emergency vent is to exhaust any excessive pressure that may accidentally build up in the tank.

Continues on page 6

Relief Vents continued from page 1

AST Specifications

Shop-fabricated tanks produced today span a wide variety of designs, configurations and associated fueling systems. Before five years ago, many of the shop-fabricated aboveground tanks consisted of single wall steel shells erected vertically or horizontally. Many tanks were, and still are, built under certain standards such as Underwriters Laboratories' UL 142, National Fire Protection Association's NFPA 30 as well as the Uniform Fire Code (UFC). These standards have been used throughout this century and written specifically for safe storage of flammable liquids. The standards include specific requirements on emergency relief venting.

Various Venting Options

There is a difference between what is referred to as "normal venting" and "emergency venting." Normal venting involves the day-to-day activity of loading and unloading the product. As the tank is filled, the pressure builds up and the tank needs to breathe out. As product is taken from the tank, a vacuum occurs and the tank needs to breathe in.

Emergency Venting

Emergency venting is intended for the special condition that can happen when a tank builds up excessive pressure at a rapid rate, such as when exposed to fire. The need for exhaust capacity in this case is much greater than that required under normal venting conditions.

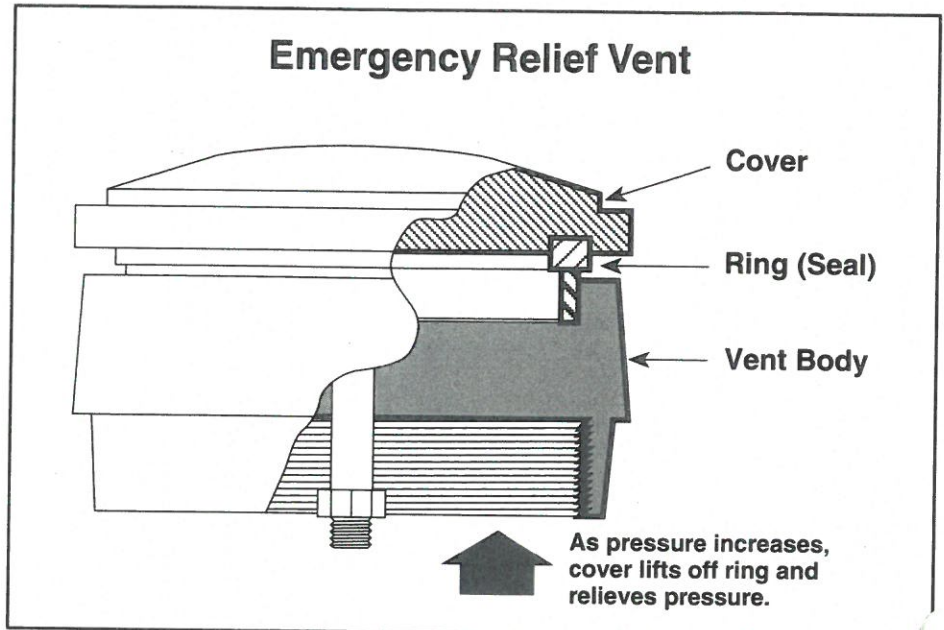
Normal Venting

Normal venting has always been a necessary feature of liquid storage and transfer. The original means may have simply been an opening in the tank. It was soon discovered that loss of product was significant over time due to evaporation and the use of popped vents became more common even before the 1920s.

Emergency relief venting was brought on as primarily a life-safety feature. Accidents have been recorded throughout the 20th century, which included fatalities, because emergency venting had not been provided on tanks. In the second half of this century, the use of emergency vents has become much more commonplace and, in most cases, provisions for this equipment are a strict legal requirement.

One analogy that helps to illustrate the

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When exposed to fire, the liquid contents of a tank will be heated and may boil, producing evolution of vapor in excess of normal operating conditions. Provisions for safely releasing this vapor are mandated by NFPA 30 through emergency venting.

concept is a tea kettle on the boil. When exposed to a fire, the liquid in an aboveground tank will heat up and build up pressure at a rapid rate. If not relieved, this pressure can get high enough in a short time to exceed the structural limits of the tank and cause it to fail. Failure in an overpressurized tank can be explosive and fatal to anyone within several hundred feet.

The emergency relief vent is designed to open under a pressure set well below the design limit on the tank to prevent overpressurization. It brings the hazards of a tank fire down to a more manageable level. With proper emergency venting in place, fire fighters have a much better chance to control the situation. Without emergency relief venting, a tank fire is unpredictable and a far greater hazard.

Emergency Vent Dimensions

The size of the emergency relief vent required relates to the size and configuration of the tank. Typically they are designed for 4-inch, 6-inch, 8-inch and 10-inch openings. The smaller sizes are normally available in female and male threaded connections and the 10-inch is flanged. The vent size must be adequate to handle the volume of air flow, or cubic

feet per hour (CFH), required for the size of tank. The larger the tank, the larger the vent.

Emergency Vent Selection

Selecting the proper size vent is not complicated, but it involves special formulas and calculations. A vent for a vertical tank is calculated with slight differences from that for a horizontal tank.

UL Standard 142 and NFPA Code 30 contain tables and charts to calculate vent sizes in the text of the code. The Morrison Venting Guide includes easy-to-follow procedures and examples for sizing vents and is recommended for those interested in knowing more about the process.

There are various styles of emergency relief vents. One style employs a weighted cover that slides up and down on a pin or shaft. The cover has a seat ring or O-ring seal and the pressure setting relates to the actual weight of the cover. When excessive pressure builds up, the cover simply lifts off the seal and allows the air to escape. When the pressure goes down, the lid goes back down.

Another type of vent has a cover that is spring loaded and hinged and set to go off

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Regional News on Aboveground and Underground Storage

Compiled by Carolyn Szabo

Yuma, AZ

A major oil corporation has been fined \$622,000 for delaying a cleanup of gasoline that leaked from underground storage tanks at a former service station in Yuma.

An assistant attorney general for Arizona said that the order is believed to be the largest penalty assessed to date in the U.S. for a lawsuit involving underground tanks.

The judge assessed a \$1,000 a day penalty against the petroleum company for failing to take what he called "appropriate" corrective action during a 622-day period ending in August 1990.

That is when the Arizona Department of Environmental Control and the state Attorney General's office filed suit to force the oil company to clean up the site where five tanks, now removed, leaked gasoline. According to the oil company spokesman, there has been no decision whether or not to appeal.

Washington, DC

A bankrupt convenience store chain will pay \$30 million to address potential contamination from leaking underground storage tanks (LUSTs) at more than 2,200 sites in 30 states.

The corporation will contribute to LUST trust funds over a six-year period to compensate the states and land owners.

Santa Rosa, CA

A company that tested underground storage tanks for leaks has been ordered to pay part of the cleanup costs for seepage from the tank.

The court decision could widen tank testers' liability for spills from the underground tanks they examine.

The tank had passed two tests in 1988 and 1989; however, a leak was found when the property owners removed the buried tank just three months after the most recent test.

The testing company was ordered to pay one-third of the cleanup costs. An appeal has not been ruled out according to the defense attorney.

Relief Vents continued from page 6

at a pre-set pressure. In this case, overpressurization causes the trip mechanism to actuate and the cover springs open. This style may need to be re-set once actuated.

A third style is a manhole cover with extra long bolts, referred to as "long bolt manhole." When relief is needed, the cover lifts up and allows vapors to escape. In this case, it is important that someone does not mistake the intended use of the device and replace the long bolts with short ones and tighten down the cover.

Alternative Venting Design

Another way to provide emergency relief venting is within the construction of the tank itself. It is referred to as a "weak roof-to-shell" design. This is illustrated in UL 142 and it consists of a special fabrication joint on a vertical tank designed to fail under a controlled limit and allow the excess pressure to escape. An emergency vent is not required on a single wall tank built to this design.

Many tanks today are being produced with a built-in dike design, double wall, triple wall, and with additional insulation to meet various environmental and fire protection criteria. Emergency relief remains a factor in these types of designs and it is typically required for each cavity capable of containing liquid. For example, in a double wall tank with an inner and outer shell, two separate emergency relief vents are required: one vent for the primary tank and the second vent for the secondary tank.

Emergency relief venting is an important, but simple, concept. Installed properly, it helps ensure a safe aboveground storage system. Even with more widespread application of aboveground storage, and with all the changes in the laws and the industry, the basic principles of emergency venting will always be the same. Understanding these principles is the best way to begin.

The Morrison Venting Guide is available in small quantities (less than 12) free of charge from Morrison Brothers Company, P.O. Box 238, Dubuque, IA 52001 or call (319) 583-5701.

Mr. Glab is vice president of sales and new product development at Morrison Brothers Company in Dubuque.

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officials we heard from were almost unanimous in their opinion that the safest place to store fuel, from a fire safety standpoint, was underground. However, because of mounting environmental concerns, they were willing to concede that small business owners needed an alternative to storing fuel underground. We then arrived at the two most important fire official concerns:

1. Fire officials want to maintain primary jurisdiction over all ASTs 12,000 gallons and under by mandating that such tanks be constructed and installed per a model fire code, and
2. All tanks 12,000 gallons and under be required to possess a minimum 2-hour fire resistance rating.

Can you provide an interpretation of the intent of the model fire code requirement paragraph within the definition for fire protected tanks which reads: "(ii) a model fire code may be

used for purposes of the 2-hour fire rated tank exclusion?"

The intent of this paragraph is to provide that any model fire codes not in compliance with subparagraph (A) of the Safe Aboveground Storage Tank Act of 1993 be updated to reflect this federal requirement.

What is required in the bill for pipe systems and why? What elements were considered with pipe systems to assure fire safety to the public?

The bill includes requirements for the upgrading of existing tanks, including the upgrading of associated piping, to new tank performance standards. Since pipe systems are often the cause of leaks from tanks, particularly if they are buried underground at large aboveground tank facilities, the requirements detail provisions requiring underground piping associated with a tank to be moved aboveground at the time the tank is upgraded unless moving the piping is infeasible because of road layouts or similar obstacles.

Two Federal AST Initiatives Await Resolution in the New Year

By Jim Wisuri
Editor

Keeping track of aboveground storage tank developments?

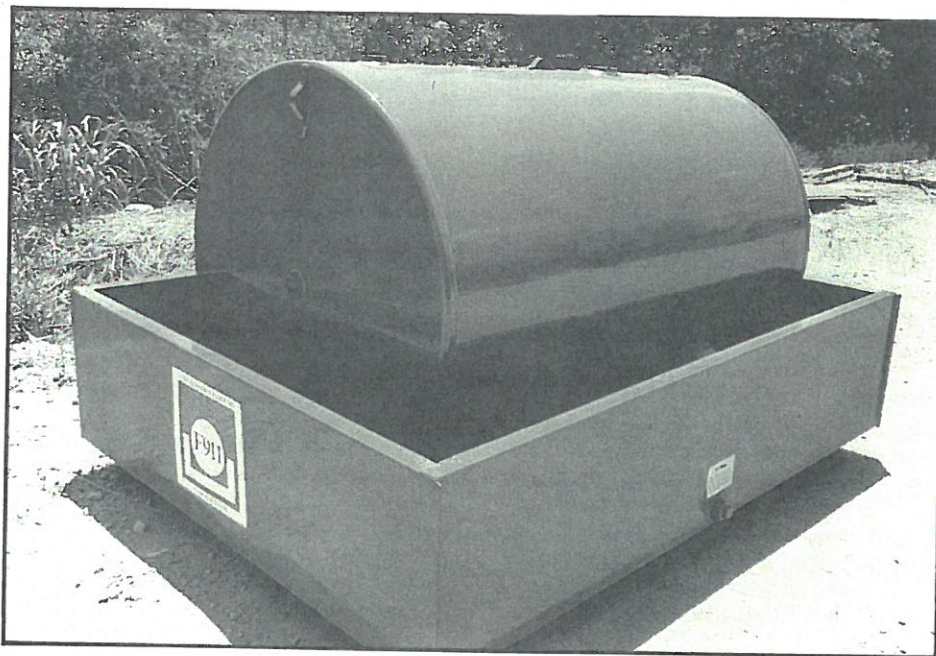
The year 1992 will be important to your examination of the topic—especially for actions on the federal level. At least one regulatory revision should be finalized, amendment to the Spill Prevention, Control and Countermeasures (SPCC) program. On a separate track, industry should learn the fate in 1992 of S. 1761, which was introduced last year by U.S. Sen. Tom Daschle (D-S.D.) to create broader regulation of aboveground storage tanks.

Here's a quick recap of prospective actions related to federal regulation and legislation:

Regulations

The 60-day SPCC comment period ended on December 23. However, U.S. Environmental Protection Agency (EPA) officials have indicated that if some "new" data became available, such information

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Federal legislative and regulatory activity in 1992 could clarify questions involving the uses of aboveground storage tanks.

Uniform Fire Code Interprets Special Enclosure Definition

By Jeffrey M. Shapiro

Subject: Special Enclosures and Aboveground Tanks at Motor Vehicle Fuel-Dispensing Stations, Sections 79.902 (c) and Appendix II-F, Uniform Fire Code, 1991 Edition

Question: Does the following tank assembly qualify as a special enclosure as specified in Section 79.902 (c) and would the enclosure be allowed as a free-standing aboveground unit at a motor vehicle fuel-dispensing station?

1. A pre-manufactured tank assembly consisting of a UL listed above-ground steel tank which is totally encased in at least 6-inch thick reinforced concrete, poured in a continuous pour such that the concrete is liquid tight and without joints.;

2. An annular space is provided between the tank and the reinforced concrete which is less than 1-inch wide; the space is provided with an inspection opening on the top of the assembly for visual inspection to observe for leaks in the primary steel tank;
3. All tank connections are installed in the top of the tank and the concrete is cast around the connections;
4. The maximum tank capacity is 2,000 gallons.

Answer: As described, the foregoing tank assembly appears to meet the intent of Section 79.902 (c) for special enclosures and it would be allowed to be installed in a free-standing aboveground configuration at a motor vehicle fuel-dispensing station provided that a determination is made

that installation underground is impractical or because of building or property limitations per Section 79.902(c). Final approval of special enclosure construction must be granted by the (fire) chief.

To foster a more thorough understanding of the history of the requirements for special enclosures and aboveground tanks at motor vehicle fuel-dispensing stations, the following discussion is offered. This expanded discussion is provided in response to continued inquiries which were apparently not resolved by our prior published interpretations on this subject.

Based upon our research, restrictions on the use of aboveground tanks used for motor vehicle fuel-dispensing date back to the mid-1900s and they resulted from

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HAZARDOUS WASTE AND SUPERFUND: Continued from page 4

held that crude oil tank bottoms are a form of "petroleum" that is exempt from Superfund liability. The opposite result was reached in the case of *United States v. Western Processing Co.* where the U.S. District Court for the Western District of Washington found that tank bottoms contain hazardous substances that form when the tank walls corrode. The resulting sludge, it said, was not exempt from Superfund liability.

Identify Contamination

The lesson here is that all petroleum-contaminated media and debris is not the same. Some of it may qualify as hazardous waste, and some of it could bring about Superfund liability if, for example, it is not disposed of properly.

Storage tank owners and operators should do four things to protect themselves: First, test the media to see what's in it; second, manage the media as "hazardous waste" if the law requires it; third, make certain the waste is handled and transported by persons who have the

necessary licenses and permits; and fourth, ensure that the waste is disposed of legally and safely.

All of these rules are complicated, expensive to comply with and may not sound fair, but ignoring them could bring about unpleasant consequences. Unfortunately, ignorance is no longer bliss.

Mr. Martin is head of the environmental law section of Williams, Mullen, Christian & Dobbins, a law firm in Richmond, Va. Copyright 1991, Channing J. Martin.

UNIFORM FIRE CODE Continued from page 1

major fire incidents which involved such tanks. Since its inception in 1971, the Uniform Fire Code has prohibited the use of aboveground tanks for the storage of Class I or Class II liquids used to dispense motor vehicle fuel. Though the code generally intends to require underground tanks for this purpose, there are cases where it is clearly impractical to use underground tanks. For example, a motor vehicle fuel-dispensing station located in a downtown area or, perhaps, in a parking garage, could have great difficulty installing tanks in an underground configuration. Section 79.902 (c) was created to recognize the need in certain circumstances to allow an alternate method to underground installation. The special enclosures required by Section 79.902 (c) are basically considered to provide comparable protection to underground configurations.

Regulations prohibiting aboveground tanks were commonly accepted until the U.S. Environmental Protection Agency implemented new regulations for underground tank installations. Specifically, the requirement for financial responsibility of tank owners has caused many tank owners to request replacement of existing underground tanks with aboveground tanks.

In response to the many questions we received regarding the application of the Uniform Fire Code to this issue, the International Conference of Building

Officials (ICBO) published interpretations of Sections 79.902 (c) and (e) in July 1989 and May 1990. Our interpretations indicated that aboveground tanks in free-standing special enclosures were equivalent to special enclosures installed in buildings; and therefore, free-standing tanks in special enclosures complied with Sections 79.902 (c) and (e).

To further clarify the allowance of aboveground tanks used for motor vehicle fuel-dispensing, the membership adopted a new appendix in the 1991 edition which gives jurisdictions a means of accepting aboveground special enclosures without the limitations of impracticality or building or property restrictions which are set forth in Section 79.902 (c). This appendix, Appendix II-F, was specifically designed to allow two configurations of aboveground tanks at motor vehicle fuel-dispensing stations. One configuration mirrors the construction requirements in Section 79.902 (c) for special enclosures. The other configuration allows tanks within enclosures or materials which provide a minimum fire resistance of two hours.

Assemblies which are designed to qualify by the two-hour protection option must be LISTED by a nationally recognized testing laboratory and APPROVED by the chief. The listing must be based upon:

1. An evaluation of the entire assembly's ability to pass a fire exposure test, and
2. An evaluation of the tank's ability to meet basic requirements for tanks

such as those prescribed in UL 142 See U.F.C. Section 2.304 (b).

Jurisdictions should be cognizant that there is not yet an approved test method for listing tanks using the "two-hour" option; and therefore, only tanks installed in concrete special enclosures in accordance with Section 79.902 (c) can presently be used to meet the provisions of Appendix II-F. Furthermore, jurisdictions should question manufacturers of pre-manufactured tank assemblies who claim to meet the "2-hour" assembly provisions to determine the basis of such claims. Evaluation based upon UL 1709 or similar tests is incomplete unless accompanied by evidence of additional tests which yielded a listing by a nationally recognized testing laboratory.

There is one additional concern which should be addressed in cases where piping is routed from the top of an aboveground tank assembly at a motor vehicle fuel-dispensing station down to the ground and then underground to remote dispensers. Though not addressed by the code, the portion of piping located between the tank and the ground should be protected from mechanical injury by either placing such piping on the far side of the tank away from traffic areas or by protecting it with substantial bollards. In recent incidents, vehicles impacting such piping caused major fires.

Mr. Shapiro is a professional engineer who serves as coordinator for the Uniform Fire Code, a publication of the Western Fire Chiefs Association.

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America's Clean-Up Dilemma

By Jim Wisuri
Editor

Pity the environmental manager who has to supervise leaking underground storage system cleanups in more than one state.

The U.S. Environmental Protection Agency's underground storage tank regulations give states great latitude in determining the standards used to determine "how 'clean' is clean."

The chart on page 4 outlines the dilemma for multi-state operators. If you have ongoing remediation projects in more than one jurisdiction, you are likely to have conflicting regulatory philosophies

with which to contend. That is especially true for those states that employ the standard of dealing with cleanup mandates on a site-by-site basis.

The chart shows more than 20 states that responded last year to a Tank Talk request for summaries of their standard operating procedures for dealing with underground storage system cleanups. The chart is interesting for a few reasons:

- It shows the similarities and differences from one state to the next.
- It shows that some states are focused enough to sum up their philosophies in a few words.
- The states not represented on the list

either were too busy to respond, or sent their entire regulatory package as a reply.

Therefore, this chart may give you some idea of how easy it will be to get an answer from state environmental officials if you are unfortunate enough to have to deal with a remediation problem.

Note: this is not a knock on environmental regulators. Many of them are simply trying to keep their heads above water with limited staffing and a seemingly bottomless pit of remediation nightmares.

The chart also shows why underground storage system purveyors who promote

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A Short History on Aboveground Storage Tank Venting

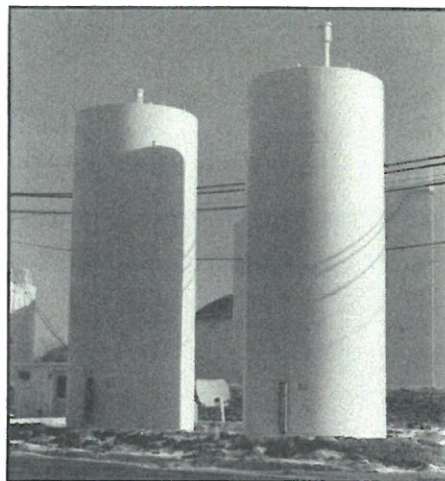
By Charlie Glab

Aboveground storage of petroleum products began commercially in the early 1900s. The earliest record of such activity at my company dates back to 1906. The principles of storing petroleum products aboveground have not changed much since the beginning. Most changes have been with fire safety and environmental control.

By 1922, an internal safety shut-off valve, operated manually by a rope, was used along with pressure vacuum vents. By 1935, the "escapement" vent, or what is referred to today as the emergency vent, was sold, and an internal-style emergency shutoff valve was also promoted.

NFPA 30 standard, (first written in 1913), was originally called "Suggested Ordinance for the Storage, Handling, and Use of Flammable Liquids". In 1957, it was changed from a municipal ordinance to a code, with all technical provisions retained. Today, this standard, along with UL 142 and API 2000, provide the basis for current design of aboveground storage facilities.

Any aboveground tank needs provision for "normal" venting, which allows the tank to "breathe" during loading and unloading. The size of this vent usually



*Aboveground storage tanks have unique requirements for proper venting.
(Tom Lampros photo)*

matches the size of the tank pipeline. A simple opening with weather protection would suffice. However, an "open" vent has no shield against evaporative loss of product.

The most popular type of "normal" or "working" vent used today is a pressure vacuum vent, often called a conservation vent. A simple pressure/vacuum poppet

arrangement seals the vapors in the tank when equalized, allowing the tank to breathe only when it needs to. Various pressure settings ranging from 2 oz. to 16 oz. are available. The vacuum is normally set at 1 oz. Lower pressure settings are favored for older tanks and normally the pressure setting for the "working" vent is set slightly lower than that of the emergency vent.

One important feature required of the "working" vent is that they be designed to discharge vapors in an outward or upward direction so in the event of a fire, the vent will not act like a blowtorch against the wall of the tank.

Concerns have been discussed lately regarding benzene emissions on aboveground storage and future requirements may include provision for vapor recovery in conjunction with the normal venting system.

Aboveground storage tanks can be equipped with a flame arrester—a device often combined with the "working" vent to provide a fire stop. Most commonly, a flame arrester incorporates a type of baffle that allows air to travel through but limits the penetration of an ignition source. The theory has been proven.

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However, a flame arrester requires regular inspection to make sure the baffle remains free of obstruction. If it becomes dirty and restricts air movement, the vent operation is limited, and could cause the tank to rupture.

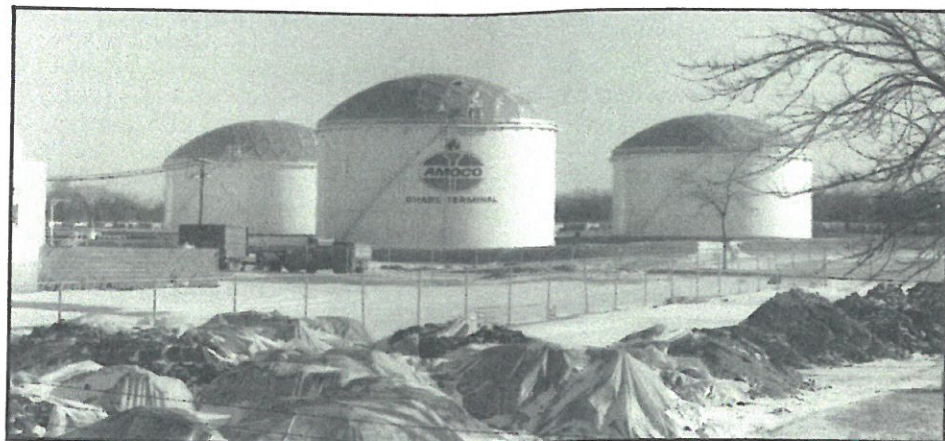
NFPA 30 identifies a maximum operating pressure of 1.0 PSI and a limit of 2.5 PSI under emergency conditions for atmospheric tanks. Most shop-fabricated aboveground storage tanks smaller than 20,000 gallons are required to be equipped with some form of emergency relief. An "emergency" vent is one way to comply with this requirement. The function of this vent is to provide adequate discharge in the event of a fire or quick build-up of pressure. The size of the vent depends on the type and size of the tank.

A tank subjected to an exposure fire acts like a teapot on the boil. Pressure builds up quickly, and without some means of relief, there is a good chance the tank will rupture in an explosive manner. The emergency vent simply blows its lid and allows the pressure to escape.

Sizing emergency vents is done by calculating the "wetted area" of the tank and finding the CFH (Cubic Feet/Hour) required. Wetted-area calculation is different for horizontal vs. vertical tanks. With the CFH requirement established, the vent size can be selected. The Morrison Vent Guide provides directions and lists the tables for sizing vents. The tables were taken out of NFPA 30, UL 142 and precalculations done for common tank sizes.

There is a limit of emergency venting requirement on tanks having wetted-surface area greater than 2,800 square feet. This is because "complete" fire involvement is unlikely. Therefore, a 10-inch emergency vent is normally the largest needed on any shop fabricated aboveground storage tank.

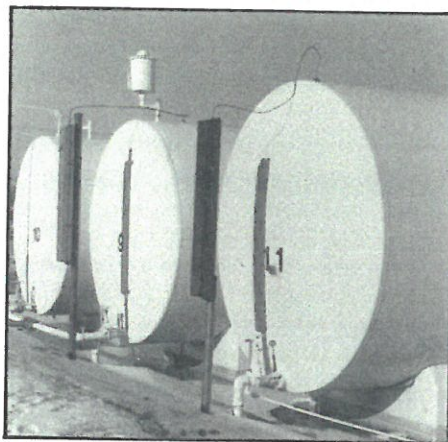
Other methods of emergency relief include a loose-bolt manhole, or weak shell-to-roof joint tanks. The loose-bolt manhole is set up with bolts that are long and kept loose so that the cover can pop up allowing pressure to escape. One concern about this is that the manhole lid often does not seal tight on the rim and vapors sneak out on a regular basis. Another concern involves the case of the over-zealous maintenance man who



New federal regulations covering both field-erected aboveground tanks...

tightens up the bolts and unknowingly eliminates the emergency relief provision for the tank.

The weak shell-to-roof joint tanks are illustrated in UL 142. These tanks are normally more expensive to fabricate and transport compared to other joint types due to the special design and fracture potential during handling.



*...and shop-built vessels are due to be proposed within a few weeks.
(Tom Lampros photos)*

Another fitting required on an aboveground storage tank, is an emergency valve or "fire valve"—located in the tank pipeline. The internal style emergency valve is fitted at the tank bottom with poppet end projecting to the inside. A spring-loaded fusible link setup on the

valve will shut off product flow in the event of fire. The valve can be equipped with a shear section, which if ruptured due to impact on the pipeline, will also shut off product flow.

The external-style emergency valve is based on the same principle and is located outside the tank in the line. The most commonly used emergency valve for aboveground storage is the internal style.

Another important principle in aboveground storage is expansion relief. Product in an external line exposed to the sun's rays will heat up and build pressure at a fast rate. Added pressure may cause the product in the line to exit weak points in the system, such as the pump/valve packing, or threaded connections. To prevent this situation, the system should be designed with adequate expansion relief that allows the product to bleed back to the tank. Gate valves and check valves can be equipped with this capability and special expansion-relief fittings can be added directly to an existing line.

A variety of new aboveground storage systems are being developed today as a result of an expanding market. The expansion is due mainly to the impact of regulations on underground storage tanks. Future regulations are expected to be extended to aboveground systems in some fashion. The tradition of fire safety, the new era of environmental control, and the influence of the everpresent pragmatic buyer will create the basis for future system designs.

Mr. Glab is vice president of Morrison Brothers Company of Dubuque, Iowa.



STORAGE TANK VENTING COMPENDIUM

ADDITIONAL RESOURCES

STI-SPFA online webinars

- Petroleum Storage Tank Maintenance Webinar 02.24.15
 - Presenters: Rick Chapman, Innospec Fuel Specialties; Brad Hoffman, Tanknology Inc.; John Albert, State of Missouri; Lorri Grainawi, STI/SPFA
- Regulation of Tanks Inside Buildings: A Guide for Code Users and Enforcers 11.5.12
 - Presenters: Jeff Shapiro and Scott Stookey
- Tank Venting Essentials: PreVENTing Catastrophe 9.7.11
 - Presenters: Jeff Shapiro and Scott Stookey

Videos

- Biodiesel Tank Explosion Video: <https://youtu.be/AAvjkiOE3Tc>
- Oil Production Tank Fire Video:
<https://www.youtube.com/watch?v=DECyAxDk88U>
- Fire kills nine in Kansas City, 1959:
<https://www.youtube.com/watch?v=FC-h534z9uA>